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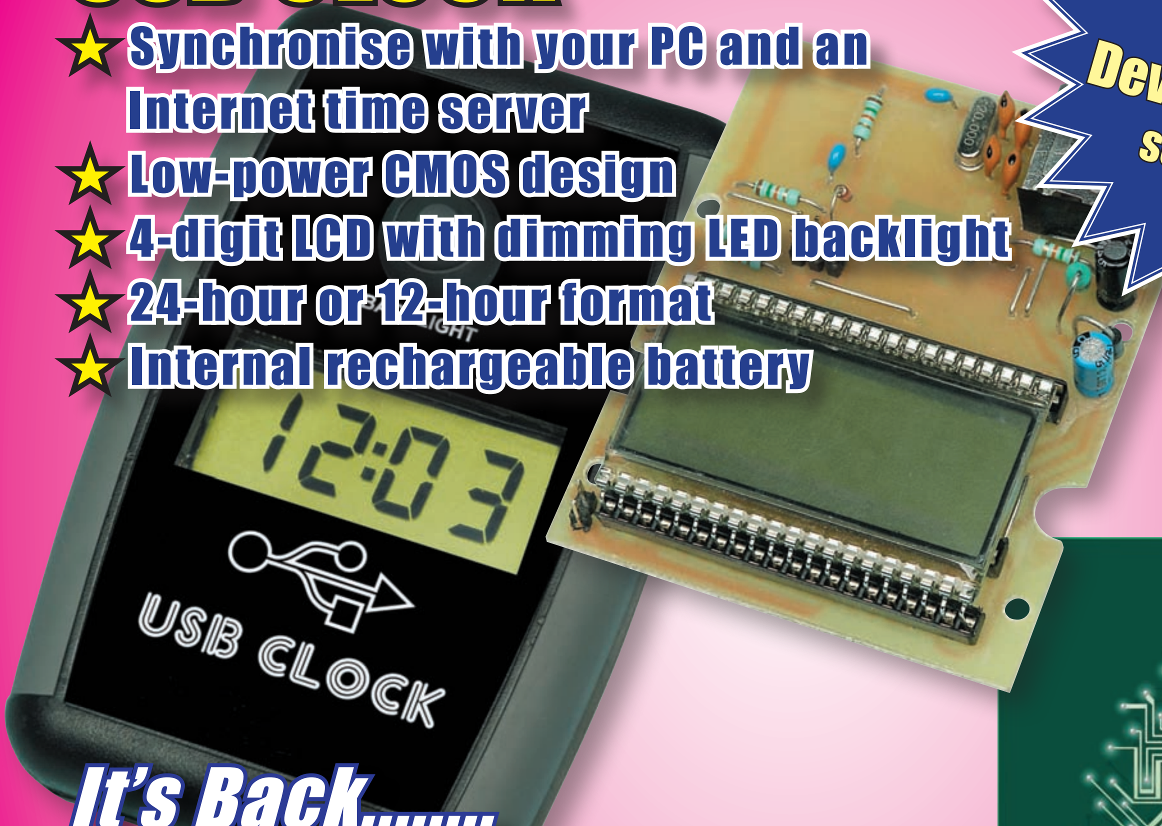

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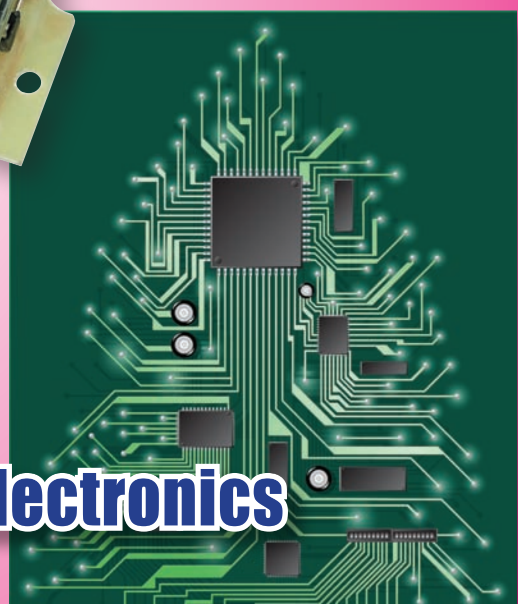

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WiFi on steroids

From the early days of dial-up, to today's 50Mb cable technology, most of us connect to the Internet via a hard-wired system. While this has enabled millions to cheaply access one of the greatest revolutions in communications, laying cable is a costly and slow business. It's also an eyesore; there are multi-occupancy buildings in my street that are covered in a poorly installed 'cobwebs' of cables. Whatever one's opinion of the aesthetics of cable installation, it's crazy that we are still using physical connection to pipe in bits.

This craziness is reinforced when you realise that as soon as broadband arrives in our homes we often abandon further cabling and opt for the flexibility of wireless connection – WiFi. The obvious question is why can't we use WiFi to cover blocks of a square mile or so, just like mobile phones. We could then abandon the installation hassle of running dedicated cables to each and every house. Well, there are a number of reasons: speed of connection, initial installation cost and interference with other spectrum users, but one major stumbling block has been a lack of spectrum space – until now, in the US at least. The US Federal Communications Commission has agreed to release blocks of unused spectrum, providing space for much more powerful WiFi.

Compared to traditional WiFi, which has a range of about a football pitch, assuming no signal-eating walls are in the way, the new system has been called 'Wi-Fi on steroids'. Its range is several miles and it can penetrate walls. A system that combines the speed of cable with the flexibility and large-scale ease of installation of WiFi would be a winner. It remains to be seen how well it works and how quickly this technology will spread, but I for one would not miss the endless cabling of my house and street!

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NEWS

A roundup of the latest Everyday News from the world of electronics

No-glasses 3D TV making headway By Barry Fox

IF NO-GLASSES 3D takes off, 'then I think Philips is sitting on a golden egg' says Maarten Tobias of Dimenco, the startup company formed by eight ex-Philips employees who previously worked for 3D Solutions – the incubator project in Eindhoven funded by Philips to develop autosteroscopic display panels.

Philips shut down 3DS in mid-2009, because its 3D panels were too expensive for consumer use. But Philips was at pains to remind that it was retaining its large folio of patents for licensing to third parties in the future. Dimenco, also based in Eindhoven on the Hi Tech Campus, is the first company to take a Philips licence. 'But it is not exclusive' says Tobias. 'Philips will licence others who want to make no-glasses screens'.

Dimenco has been working to improve the panels made by Philips 3DS, and was demonstrating the results with a 56-inch screen on the Philips stand at the *IFA* show in Berlin, under the banner '3D of the Future'.

The new panels double resolution from Full HD 2K to 4K (from 1920 × 1080 to 3840 × 2160), and this lets the screen display 15 graded views, ranging from 'full left' to 'full right' behind a lenticular screen with 15 vertical lens slices. This gives viewers far sharper pictures over a wider viewing angle – 120 degrees. The original panels could show only nine views.

The demo material shown at *IFA* was specially shot, as a 2D-plus-depth signal; a 2D image is accompanied by a bit map that describes the depth of objects in the scene. Processing in the panel converts 2D+Depth to the required 15 views in real time, on the fly.

The next step will be to convert or 'render' stereo material; eg, from a 3D BD, to 2D+Depth on the fly. It will then be possible to play 3D BDs through the display for no-glasses viewing. 'Real time rendering is definitely possible', says Tobias.

'The advantage of using 2D+Depth is that you give the user control over the depth of the image, which is not possible with existing systems.'

Currently, the 4K panel cost is still too high for consumers, around 40,000 euros (approx £33,000) for the 56-inch screen. 'But if you buy hundreds it would be less' assures Tobias. 'And we are working on a Full HD (2K) 52-inch monitor, which could be sold for around 5000 or 6000 euros.'

'There is no standard for autostereo yet. But we expect it will be something the BDA takes on. And 2D+Depth is already in the MPEG and HDMI 1.4 standards'

'We see the 4K panels as being ideal for signage or medical applications. It's likely that the first consumer applications will be for photo frames, which are smaller and where the consumer is less sensitive to quality. We expect consumer products in three to five years.'

The 3D demos on the 4K panel at *IFA* showed an interesting bonus effect; if the viewer's head is tilted to one side, then the image degrades gracefully to 2D, rather than collapsing into eye-confusing distortion as on some 3D systems that are viewed with glasses.

GIANT CAMERA SENSOR

PHOTOGRAPHY equipment company Canon has announced the development of an APS-H CMOS sensor that delivers an astonishing 120 megapixels — the largest CMOS sensor in the world.

In the photo above, the sensor is shown next to a standard 35mm full-frame sensor. The giant photon catcher measures 202 x 205 mm, or 40 times the size of current sensors, and is extremely sensitive.

The ability to record 60fps video under moonlight is claimed, and potential applications include capturing the night sky and documenting nocturnal animal behavior.

A high resolution (300DPI) print from this device would be nearly a square metre in size, and to view the file at 100% (at 72 DPI) would require a 4m square monitor.

US Department of Defense aims for extreme scale supercomputers

NOTING that 'Advanced computing is the backbone of the Department of Defense and of critical strategic importance to our nation's defense.', the US Department of Defense (DoD) has set itself an ambitious target to leapfrog Silicon Valley's famous – and to date reliable – Moore's Law of computer evolution.

In a press release, the DoD stated that: 'All DoD sensors, platforms and missions depend heavily on computer systems. To meet the escalating demands for greater processing performance, it is imperative that future computer system designs be developed to support new generations of advanced DoD systems and enable new computing application code.

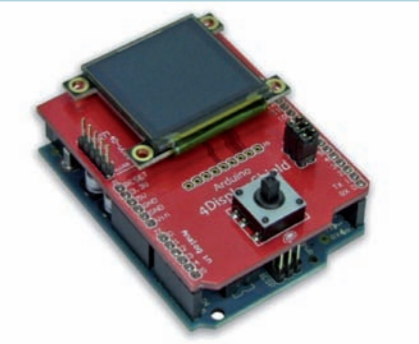
'Targeting this crucial need, the Defense Advanced Research Projects Agency (DARPA) has initiated the Ubiquitous High Performance Computing (UHPC) program to create an innovative, revolutionary new generation of computing systems that overcomes the limitations of the current evolutionary approach.

'Computing performance increases have been driven by Moore's Law (doubling the transistors that can be placed on an integrated circuit every two years). The ability to achieve projected performance gains is limited by significant power consumption, and architectural and programming complexity issues. To exploit available technological advances fully, highly programmable high performance computers must be developed that require dramatically less energy per computation.

'The goal of DARPA's UHPC program is to re-invent computing. It plans to develop radically new computer architectures and programming models that deliver 100 to 1,000 times more performance, and that are easier to program than current systems.

'The resulting UHPC capabilities will provide at least 50-times greater energy, computing and productivity efficiency, which will slash the time needed to design and develop complex computing applications. Prototype UHPC systems are expected to be complete by 2018.'

Arduino Display Shield modules

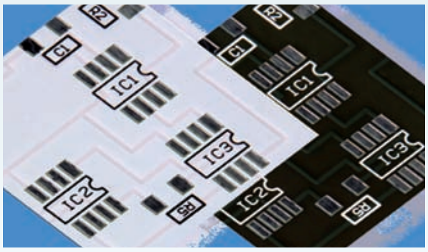


4D Systems has launched its new range of Arduino Display Shield modules. They provide an easy and fast way of interfacing the popular GOLDELOX-embedded range of OLED and LCD display modules with virtually all popular Arduino boards, such as the Arduino-Duemilanove and Arduino-Mega, as well as many other compatible boards.

The 4Display-Shields come complete with the integrated 4D Systems OLED or LCD display module, a 5-way multi-switch joystick, and male headers that help connect the 4Display-Shield to the Arduino Boards. The 5-way joystick is connected to the Arduino D2, D3, D4, D5 and D6 pins, and communication between the 4Display-Shield and the Arduino takes place via the serial UART. The included display modules, ranging from tiny 0.96-inch form factor up to a 1.7-inch full colour OLED screen, include a tiny yet powerful GOLDOX graphics controller chip and a microSD connector that supports standard and HC memory cards, which can be used for storing images, icons, video clips and data.

Prices range from \$39 to \$63 (£33 to £53 approx). All modules are available for purchase from local 4D distributors or resellers, or directly from 4D Systems. All related software tools are available as a free download from 4D Systems' website at: **www.4dsystems.com.au**.

New IMS prototyping service from PCB-POOL



PCB-POOL, the manufacturer of prototype printed circuit boards, has announced the introduction of a new metal core (insulated metal substrate (IMS)) PCB prototyping service.

Metal core PCBs are designed to transmit heat away from operating areas on the PCB or components to less critical areas, such as metal heatsink backing and metallic core.

Designers of high intensity LEDs, power converters, automotive applications or any circuits requiring greater heat dissipation can now take advantage of reduced pricing and shorter lead-times offered within this new PCB-POOL service. Various machining methods have been integrated in the IMS manufacturing process, including the ability to produce threaded drills holes, counter sinking and controlled depth milling using the latest CNC technology. With IMS printed circuit boards, instead of the usual base material, aluminium is used as the carrier for copper.

What's on offer?

- *One layer IMS PCBs*
- *No minimum quantity*
- *Various soldermask and silkscreen colours available*
- *No tooling or set-up charges*
- *Lead-free HASL surface finish*
- *1.5mm thickness*
- *100µm isolation layer*
- *35µm copper*
- *FREE laser SMT stencil with all prototype orders.*

Find out more at: ***www.pcb-pool.com****; or call on FREE PHONE UK 0800 389 8560; email to: sales@pcb-pool.com.*

Technobots opens new electronics shop

FOLLOWING continued growth in their electronic components range, Internet-based company Technobots has opened a retail outlet in Totton, Hampshire, stocking their full range of electronic and mechanical components.

Now in their tenth year of trading, Technobots offers 5100 products, including specialist hobby electronic components from manufacturers such as Sparkfun, Pololu and Canakit.

According to Paul Cooper, Technobots MD, 'we are really encouraged by feedback about the new Totton store. Customers have warmly welcomed the new outlet for components in the Southampton area, and appreciate being able to source a timing pulley or bearing for an Arduino controller project, all from one store'.

EPE readers can get the Technobots 120-page A4 catalogue free with their next order by quoting **EPE05**. For more information, see the Technobots advert on page 59. You can visit Technobots' website at: **www.technobotsonline.com.**

Photoshop Express app

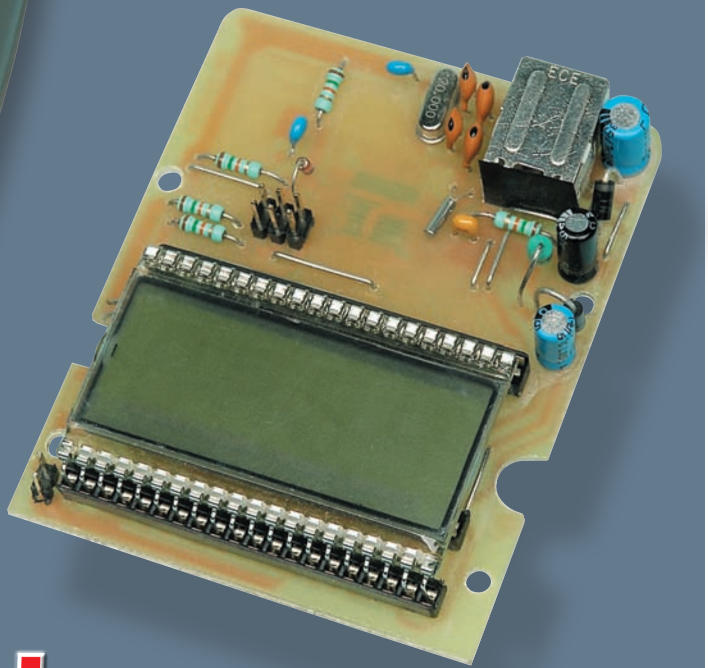
IMAGING software giant Adobe has developed an on-the-go iPhone/iPad 'app' for processing photographs taken with, or stored on Apple iOS 4 devices. 'Photoshop Express' is easy to use, simply drag your finger to edit or apply effects, for example:

- Crop, rotate, change colour with just a touch
- Give an extra glow with soft focus
- Get artsy with sketch
- Apply one-touch effects like warm vintage and vignette
- Try any edit — you can undo it.

The full Photoshop program for PC or Mac is not cheap, but Adobe have been generous with this app, and it is available for free download from their website, see: **http://mobile.photoshop.com/iphone**

Photograph processed using the Photoshop Express app: top – original photograph, middle – multi-coloured mosaic; and bottom a cropped, flipped and 'sketch' stylised version of the original. (Thank you model Shirley!)

For the advanced constructor . . .



USB Clock With LCD Readout

Part 1: By MAURO GRASSI

This LCD USB Clock connects to your PC's USB port. It synchronises its time with your PC – and ultimately an Internet time server – when your PC is on to maintain accurate time-keeping. It can also operate on its own using battery back-up, and has user-selectable display modes.

ALL recent PC operating systems, including Windows, provide services for NTP (Network Time Protocol), a protocol that's used to synchronise your PC's local time with an Internet time server. This USB Clock in turn synchronises with your PC's clock, and provided you boot your PC regularly (and synchronise it to an Internet time server), it will maintain accurate timekeeping.

In use, the USB Clock is powered via the PC's USB port when the PC is on. This also charges an internal NiMH battery. This battery powers the clock when the PC is off or when the clock is disconnected from the USB port.

When the PC is off, the clock's time-keeping is maintained by a 32.768kHz watch crystal. This is accurate to within ±20ppm, giving a timekeeping accuracy of better than two seconds a day in stand-alone mode.

Control software

By now, you've probably guessed that the LCD USB Clock is based on a microcontroller. In this case, we're using a PIC18F4550 micro to provide all the necessary functions.

In addition, a small command-line program (**usbclock.exe**) is used to change the USB clock's settings and to synchronise the clock's time with your PC's clock. This will be described next month. We'll even show you how to

set-up your Windows operating system (using an entry in the Start-up folder) to automatically synchronise the USB Clock to the PC's clock each time the machine boots.

That way, you can install the software and forget it. In fact, this system will even take care of daylight saving time shifts. When your PC automatically adjusts for daylight saving, it automatically adjusts the USB clock as well (when it is next synchronised).

Display modes

This clock doesn't just tell the time – that would be far too easy! Since it has a microcontroller, we can do all sorts of other stuff as well, such as displaying the time in either 24-hour or 12-hour format; displaying the date; displaying the charging current or the battery voltage; and scrolling the display.

Basically, there are 12 different display modes; Table 2 shows the complete list.

So how do we step through these different display modes? Well, you can either do it by repeatedly pressing the front-panel pushbutton switch (S1) or you can use the **usbclock.exe** program.

For example, if you press the switch once, the backlight comes on. Press it again and the LCD shows the day and the month in DD:MM format (ie, mode 1). Press it again, and the display steps to mode 2 to show the year, and so on.

As stated, there are 11 display modes in all, the last two bring up scrolling displays. Mode 9 scrolls the time and the date, while mode 10 scrolls the time only.

Prefer to control the clock via your computer's keyboard instead? No problem – just type **usbclock.exe -z:X** at a command prompt, where 'X' is a number between 0 and 11, depending on the mode you want displayed.

Want to display the date? Type **usbclock -z:1**. Want the battery charging current? Type **usbclock -z:4.**

Once the selected mode has been displayed, the display automatically reverts to the default display mode at the end of a preset time-out, which has a default value of 30 seconds, but this can be changed if you wish.

Naturally, you can also change the default display mode if you want. For example, you might want the LCD to show the date (mode 1) by default instead of the time (mode 0). We'll talk more about this in Part 2 next month.

Advanced constructors only

This project uses a number of surface-mount ICs (including the microcontroller) which means that very good soldering skills are necessary in order to build it. In addition, you may have to fiddle with your PC's firewall (if you use a third-party firewall) as well as the one on your modem, to get your PC to synchronise with an internet time server. Therefore, we regard this project as being suitable for advanced constructors only.

Backlight display modes

An optional LCD backlight module allows the display to be read in the dark. There are three different user-selectable modes for this backlight:

1) Backlight always on mode: the backlight is always on when the clock is plugged into a USB port.
2) Automatic mode: the backlight automatically switches on between 6pm and 6am (ie, 18:00 and 06:00 hours), which means that the backlight automatically switches on at night. Note: the unit must be connected to a USB port for this mode to operate.
3) Pushbutton only mode: in this mode, the backlight comes on for a preset time only when the front-panel pushbutton is pressed. The default time is five seconds, but this can be set for longer periods if necessary.

When the clock is operating from battery power, only the third backlighting mode (pushbutton mode) is available. In addition, the backlighting function is automatically disabled if the battery discharges below a preset voltage. This is done to conserve battery life and maintain timekeeping when no USB power is available for extended periods.

The current drain without backlighting is typically below 1mA. This increases to about 200mA when the backlight is on at 100% duty cycle.

How it works

The complete circuit of the LCD USB Clock is shown in Fig.1. As can be seen, it consists of a microcontroller (IC1), an LCD and a bit of supporting circuitry.

The LCD is driven via two D-type octal transparent latches (IC2-IC3). These latches are only needed because there are not enough I/O pins available on the microcontroller.

In operation, the microcontroller loads a 16-bit word into the latches to drive the segments of the LCD. Just how the LCD is driven is explained in some detail later.

Power for the circuit is derived from the USB port on the computer, and is fed to pin 1 (+V) of a USB Type-B socket. This pin is nominally at +5V, although in practice, it can be anywhere between 4.75V and 5.25V, ie, 5V ±5%.

Diode D1 provides reverse polarity protection for the USB Clock's circuitry. It also ensures that, when the PC is switched off (but the USB cable is left connected), the battery cannot discharge back into the PC's USB port.

When USB power is applied, the supply rail sits at about 4.4V. This is sufficient to power the circuit and to trickle-charge the three AAA NiMH cells used for the back-up battery.

Main Features

- Automatically synchronises its time with your PC, and by extension, an internet time server
- Internal rechargeable battery to keep the time while disconnected from the PC
- 4-digit LCD with optional dimming LED backlight
- All settings are changed by connecting to a PC
- Can display supply voltage and battery charge status, as well as date and time
- Low-power CMOS design for extended battery life
- Automatic backlighting mode
- Displays time in either 24-hour or 12-hour format.

Pin	Function	Details
1	V_{PP}	Programming voltage (typically 13V)
2	PGC	Programming clock signal
3	GND	Ground reference
4	GND	Ground reference
5	V_{DD}	Supply voltage (typically 5V)
6	PGD	Programming data signal

Table 1: this table shows the pin-out of the ICSP (in-circuit serial programming) header CON1. It can be used to program IC1 in-circuit using a programmer like the dsPIC Programmer featured in the May 2010 issue of *EPE*. Other programmers, like Microchip's PICKit2 can also be used, by connecting the pins appropriately.

The 4.4V supply rail is bypassed using a 47µF electrolytic capacitor.

Two 3.3Ω resistors connected in parallel (to give 1.65Ω) are used to limit the charging current through the battery. In addition, the voltage across these resistors is directly proportional to the charging current, and this voltage is applied via a 15kΩ resistor to the AN1 (pin 20) input of IC1. As a result, the applied voltage is digitised, and the resulting value is then used by the firmware to detect when the USB cable is disconnected.

When that happens, the battery supplies power for the clock and the AN1 input sits at a small negative voltage with respect to ground. The 15kΩ resistor in series with the AN1 input limits the input current to avoid damage to this input. The 100nF monolithic capacitor bypasses the applied voltage signal.

The other 100nF capacitors are used to bypass the main supply rail, while the 220nF capacitor is used to bypass the output of IC1's internal 3.3V regulator at pin 37 (this is used to run the on-board USB transceiver).

Crystal clocks

A 20MHz crystal (X1) is used for the USB system and as the system clock. This crystal is connected between pin 30 and 31 of IC1, while the two associated 15pF capacitors provide the correct load to ensure that the oscillator starts reliably. An internal PLL multiplication stage and division stage are then used to derive a 48MHz clock, which is used by the USB system.

Crystal X2 is a standard 32.768kHz watch crystal ($32,768 = 2^{15}$) and is used for timekeeping. Its tolerance is less than 20ppm (parts per million) and it gives quartz watch accuracy, typically a second or two per day (or a minute per month at worst). However, this is only relevant if the USB Clock is not synchronised regularly with the PC.

The two associated 22pF ceramic capacitors provide the correct loading for this crystal.

Display Mode	What's Shown On The LCD
0	Time is shown as HH:MM (hours:minutes) with the colon toggling at 2Hz (eg, 22:25 indicates it is 10:25pm).
1	Date is shown as DD:MM (day:month) (eg, 17.07 indicates 17 July).
2	Date is shown as YYYY (year) (eg, 2008 indicates the year 2008).
3	Time is shown as MM:SS (minutes:seconds) with the colon toggling at 1Hz (eg, 25:59 indicates 25 minutes and 59 seconds past the hour).
4	Battery charging current is shown in amps (eg, C.074 indicates 74mA).
5	Supply voltage is shown in volts (eg, b4.48 indicates 4.48V).
6	Battery charge state is shown in % (eg, b100 indicates 100% charge).
7	Shows the current backlight PWM duty cycle as a percentage (eg, P080 indicates 80% duty cycle).
8	The current state of the USB enumeration is shown as a number (eg, Usb6 indicates the clock is CONFIGURED and ready to receive data). 0: DETACHED state 1: ATTACHED state 2: POWERED state 3: DEFAULT state 4: ADDRESS PENDING state 5: ADDRESSED state 6: CONFIGURED state
9	The time and date are shown as a scrolling string.
10	The time is shown as a scrolling string.
11	Displays firmware version (eg, F1.00 refers to version 1.00).

Table 2: the USB Clock has 12 display modes, as listed here. You step through them by repeatedly pressing switch S1 or by using the *usbclock.exe* program.

Measuring the supply voltage

As mentioned, IC1's V_{USB} pin (pin 37) is the output of the microcontroller's internal 3.3V voltage regulator. This output is fed directly to the AN0 ADC input at pin 19.

Since this voltage sits very close to 3.3V, this allows the microcontroller to measure its own supply voltage. This can be used to detect a low voltage condition and thus disable the backlight operation accordingly.

Backlight circuit

The backlight consists of four LED pairs connected in series (note: these are part of a complete module). This is preferable to a parallel connection because it ensures that the LEDs have exactly the same current flowing through them at all times, thus ensuring equal brightness.

The downside of a series connection is that you need a much higher driving voltage, in this case around 16V, since the forward voltage drop of each LED pair is around 4V. This stepped-up voltage is derived using IC4, which is an LM3519 'high-frequency boost white LED driver'.

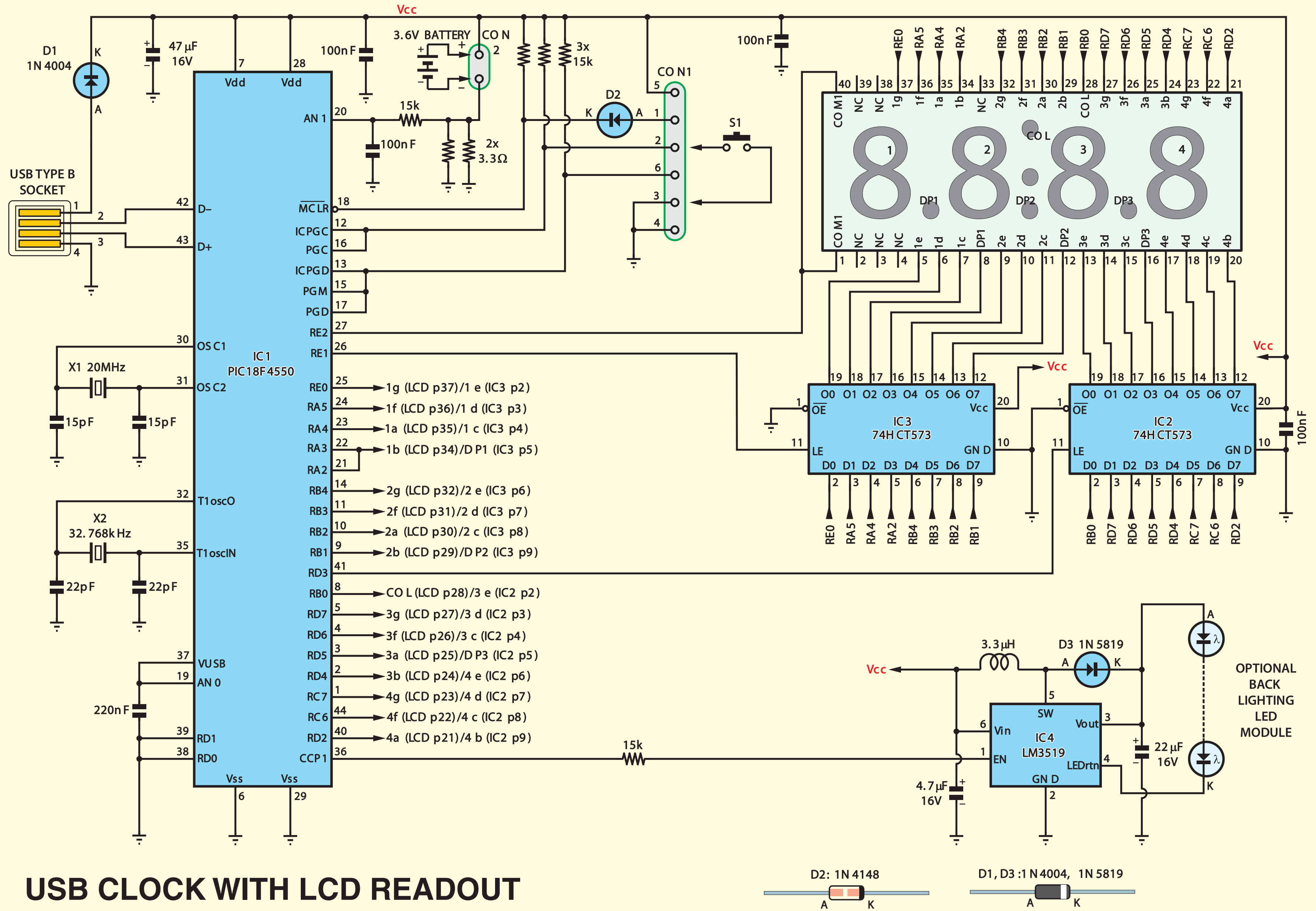
In operation, IC4 works from a supply rail as low as 2.7V, and can generate a constant 20mA through the LEDs. A 3.3µH RF choke, Schottky diode D3 and the 4.7µF and 22µF bypass capacitors complete the backlight driver.

The brightness of the backlight is controlled via the enable (EN) input (pin 1) of IC4 using PWM (pulse width modulation) from pin 36 (CCP1) of IC1. The PWM frequency generated by IC1 is around 30kHz, and the duty-cycle is set by the firmware. In particular, the firmware automatically reduces the duty-cycle (and thus the backlight brightness) if it detects that the battery is 'buckling' under the load.

Note that IC4's 'shutdown' current is less than 1µA, making it ideal for battery-powered applications.

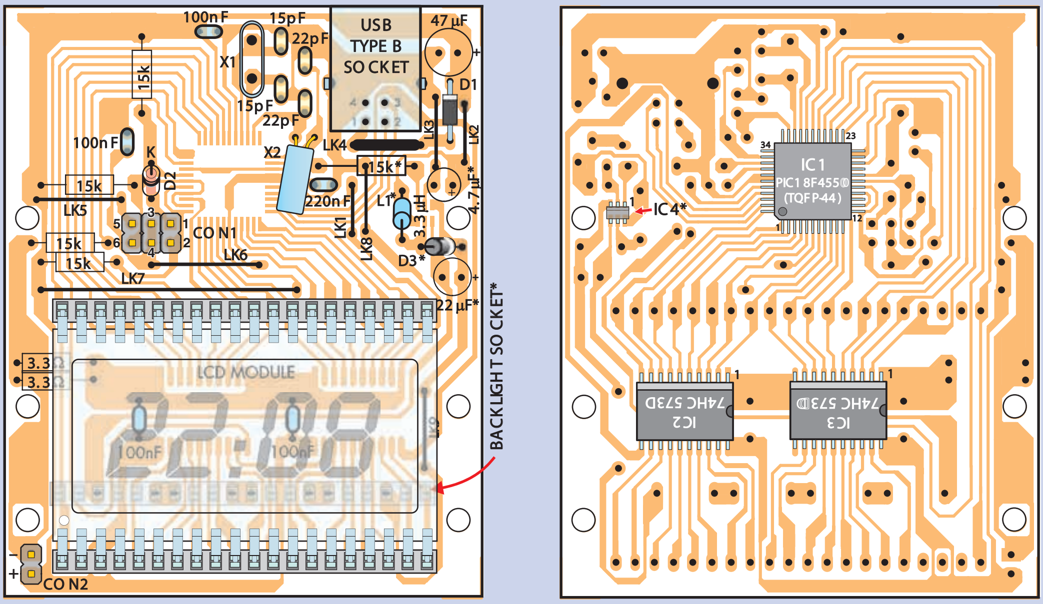
Pushbutton switch

Six-way header CON1 is used to connect pushbutton switch S1 between pins 12/16 of IC1 and ground. Pins 12/16 are normally pulled high



USB CLOCK WITH LCD READOUT

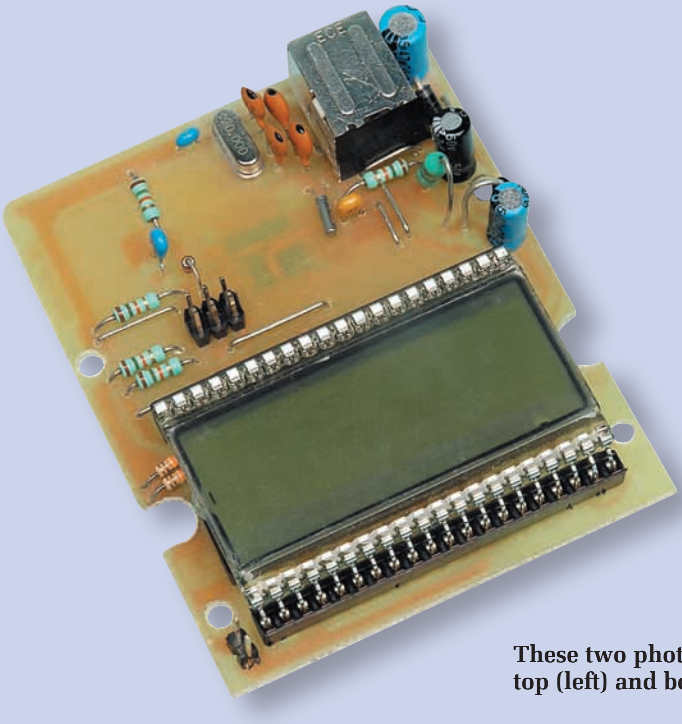
Fig.1: the circuit of the LCD USB Clock is based on a microcontroller (IC1) and a 4-digit LCD readout. Power comes from the USB port of a PC or from a 3.6V rechargeable NiMH battery. IC4 and its associated circuitry are used only for the optional backlighting feature.

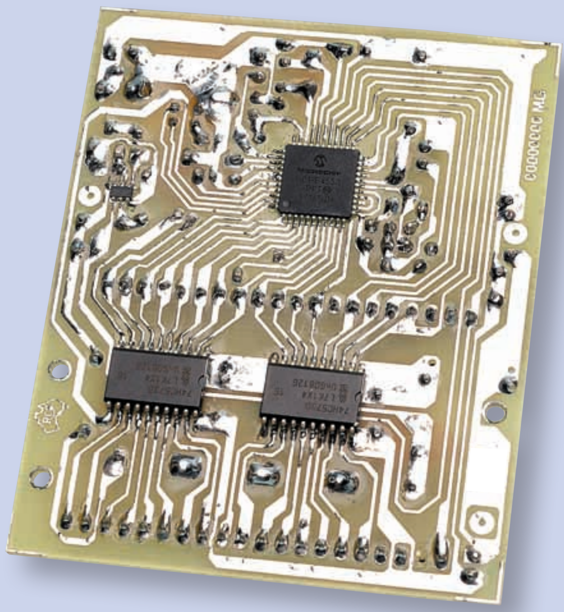


TOP OF BOARD

UNDERSIDE OF BOARD

Fig.2: follow these layout diagrams to install the parts on the top side and on the underside of the PC board. The parts marked with an asterisk are installed only if the optional backlighting is required (see text).





These two photos show the fully-assembled USB Clock module from the top (left) and bottom (right).

via a 15kΩ pull-up resistor, but are pulled low each time S1 is pressed.

This switch is used to turn on the backlighting and to step through the different display modes (see Table 2).

In addition, CON1 can also be used to program the microcontroller in circuit (ie, it also functions as an ICSP header). ICSP (in-circuit serial programming) is a vital requirement for any SMD microcontroller, as these are more difficult to program 'out of circuit' than standard through-hole parts.

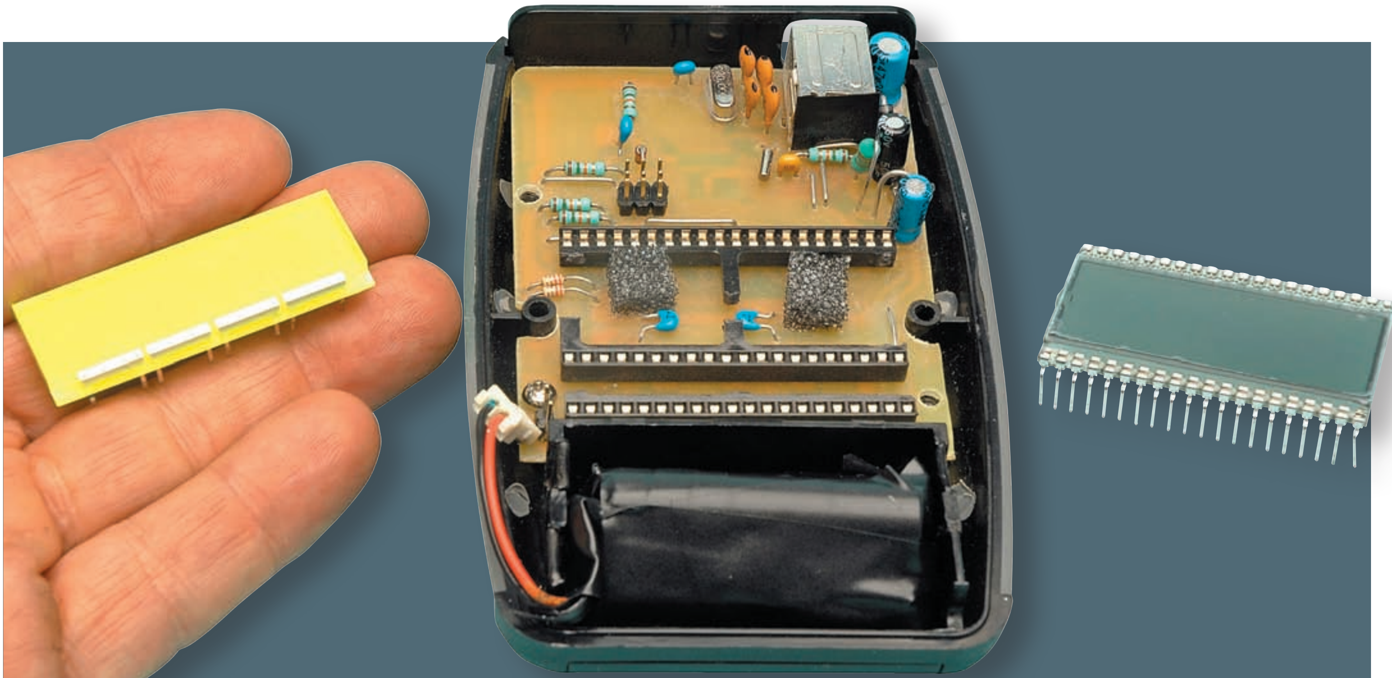
If you buy the USB Clock as a kit, then the microcontroller will be preprogrammed and you will not need to use this connector. By contrast, the 'home-brew' constructor can use this connector to program the microcontroller using the hex file that's available from the *EPE* dowload site at: **www.epemag.com**.

The ICSP pin connections for CON1 are shown in Table 1.

The other header, CON2, is used to connect the standalone power source – the rechargeable battery pack (3 × 900mAh AAA NiMH cells).

Driving the LCD

The firmware is responsible for all the clock functions, as well as driving the LCD. In operation, the display segments are driven by a square wave with a frequency of about 25Hz. A segment is *on* whenever its driving signal is out of phase with the backplane signal (at pins 1 and 40). Conversely, a segment will be *off* whenever its driving signal



This photo shows the fully-assembled PC board before installation of the backlight and the LCD. Note the foam blocks which are used to support the backlight.

is in phase with the backplane drive. The segment contrast is proportional to the RMS of the voltage applied to the segment relative to the backplane.

Basically, we need 33 driving signals (28 for the LCD's four 7-segment digits, four for the decimal points and the colon and one to control the backplane). In this circuit, however, the microcontroller (IC1) drives the display segments using just 18 lines. It does this by driving 16 segments directly, while the other 16 segments are driven by loading two 8-bit bytes (ie, from the same microcontroller outputs) into D-type octal transparent latches IC2 and IC3.

This latching occurs very quickly (within nanoseconds), thus ensuring that the segment drive is very close to 50% duty cycle. This is important to minimise the DC offset across the LCD segments, as excessive DC offset can destroy this kind of display.

Pin 27 of the microcontroller provides the LCD's backplane signal. This directly drives pins 1 and 40 of the LCD.

Full-speed (12Mbps) USB 2.0

Another job of the firmware is to service the USB 2.0 port. Endpoint 0 is implemented, as that is mandatory for any USB device. Endpoint 1 is implemented as well, and uses 64-byte data packets. These packets are used to communicate with the host program (**usbclock.exe**) on the PC via a custom Microchip driver (MCHPUSB).

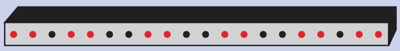
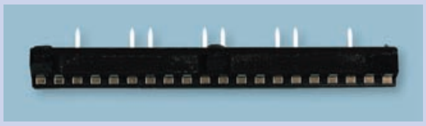


Fig.3: the 20-pin socket strip for the backlight is modified by removing the pins indicated in red.



The pins are removed from the 20-pin socket strip by cutting them off flush using sidecutters, as shown at left. The photo above shows the modified socket strip.

Each time the host program on the PC sends a 64-byte packet, the microcontroller in the USB Clock decodes it (according to the sent command) and updates its settings accordingly. The time is sent as a time data type, consisting of the hours, minutes, seconds, day of the week, day of the month, day of the year and year.

In addition, the microcontroller keeps an internal record of the last successful synchronisation with the host.

If the packet is successfully transmitted, the USB Clock sends a 64-byte packet back to the host program. It contains information on all the relevant settings of the USB Clock, and these can be accessed by running the **usbclock.exe** program with the information option (ie, by typing **usbclock -i**).

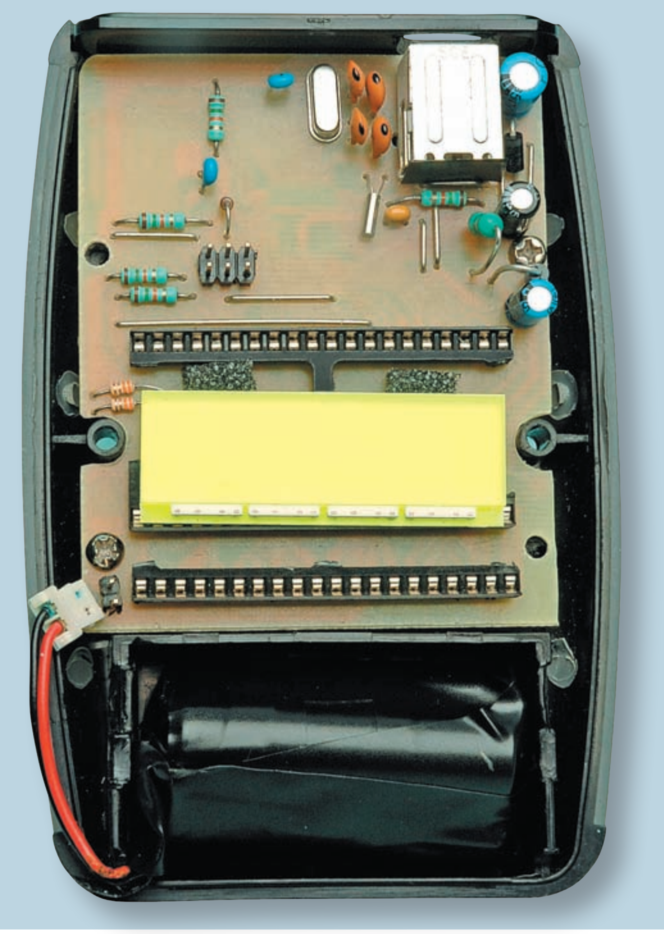
Next month, we'll explain how to use the command line program **usbclock.exe** to communicate with and synchronise the USB Clock. This program can also be used to change various default settings.

Software

The software files are available for free download via the *EPE* Library site, accessed via **www.epemag.com**.

Construction

Building the USB Clock requires good soldering skills, since a number of SMDs (surface mount devices) are used. However, the SMDs used have a relatively large pin spacing, so the job should be fairly straightforward.



The backlight plugs into the modified centre socket strip, so that it sits directly under the LCD.

Backlight and LCD options

If you decide to omit the backlight, use the reflective LCD module from Jaycar (Cat. ZD-1886). Reflective LCD modules reflect the polarised ambient light to create the contrast for the segments. However, they do not let light pass through from underneath and are therefore unsuitable for backlighting.

If you do wish to have a backlight, you must use a trans-reflective LCD module instead (eg, Farnell Cat. 1989340). A trans-reflective LCD module differs from a reflective module in that it lets some light pass through from underneath, thus making it suitable for backlighting.

The specified reflective and trans-reflective modules are pin-for-pin compatible, so either will work in this circuit. They are both 4-digit static LCD displays that consume very little power, and so are ideal for battery-powered applications.

All the parts are mounted on a single PC board, code 779, measuring 63mm × 78mm. This board is available from the *EPE PCB Service*. Fig.2 shows the parts layout and wiring details.

Note, those parts marked with an asterisk are installed only if you intend fitting the optional backlight. Note also, that if the backlight is fitted, you will need to use a transreflective 4-digit LCD, as specified in the parts list.

Begin construction by inspecting the PC board for hairline cracks in the copper tracks and for shorts between closely-spaced tracks. That done, start the assembly by installing the wire links. There are nine of these, including one under the right-hand side of the LCD.

Use tinned copper wire for the links. It can be straightened by clamping one end in a vice and then stretching it slightly by pulling on the other end with a pair of pliers. The resistors go in next. Their values can be checked using a DMM, before insertion.

The three diodes are next. Note that these are all mounted vertically on the board. Make sure that all the diodes are correctly oriented and note that D1 is a 1N4004, while D3 is a 1N5819.

The 3.3μH RF choke (L1) can now be soldered into place. This also mounts vertically on the board. It looks like the resistors, so don't get it mixed up with these parts (it should have a very low DC resistance).

Now fit the four ceramic capacitors (2 × 15pF and 2 × 22pF). These are all located immediately to the left of the USB socket. Once they're in, install the five monolithic capacitors (4 × 100nF and 1 × 220nF) and the three electrolytics. Make sure that the electrolytics are all correctly oriented.

Follow these with the two crystals (X1 and X2). The 32.768kHz watch crystal (X2) has very delicate leads, so be careful with these. This crystal should be mounted so that it sits horizontally on the PC board. Secure X2 in place with a small dab of silicone to prevent it from moving and fracturing its leads after it has been installed.

Cutting the IC sockets

The next step is to cut the two 40-pin IC sockets in half to obtain three 20-pin strips (the remaining strip is discarded). Two of these 20-pin socket strips are used to mount the LCD, while the other is used to mount the backlight module.

We recommend that you leave part of the middle connecting bar on the top socket strip (see photos) to provide support for the backlight module. The two socket strips for the LCD module should now be soldered into position.

The socket strip for the backlight module can now also be mounted, but first you have to remove a number of pins. This is done by snipping them off using side-cutters, as follows: beginning on the left, remove two pins, then leave one, remove two, leave two, remove two, leave two, remove two, leave two, remove two, leave one, remove two (ie, 12 removed in total). Fig.3 shows the pattern.

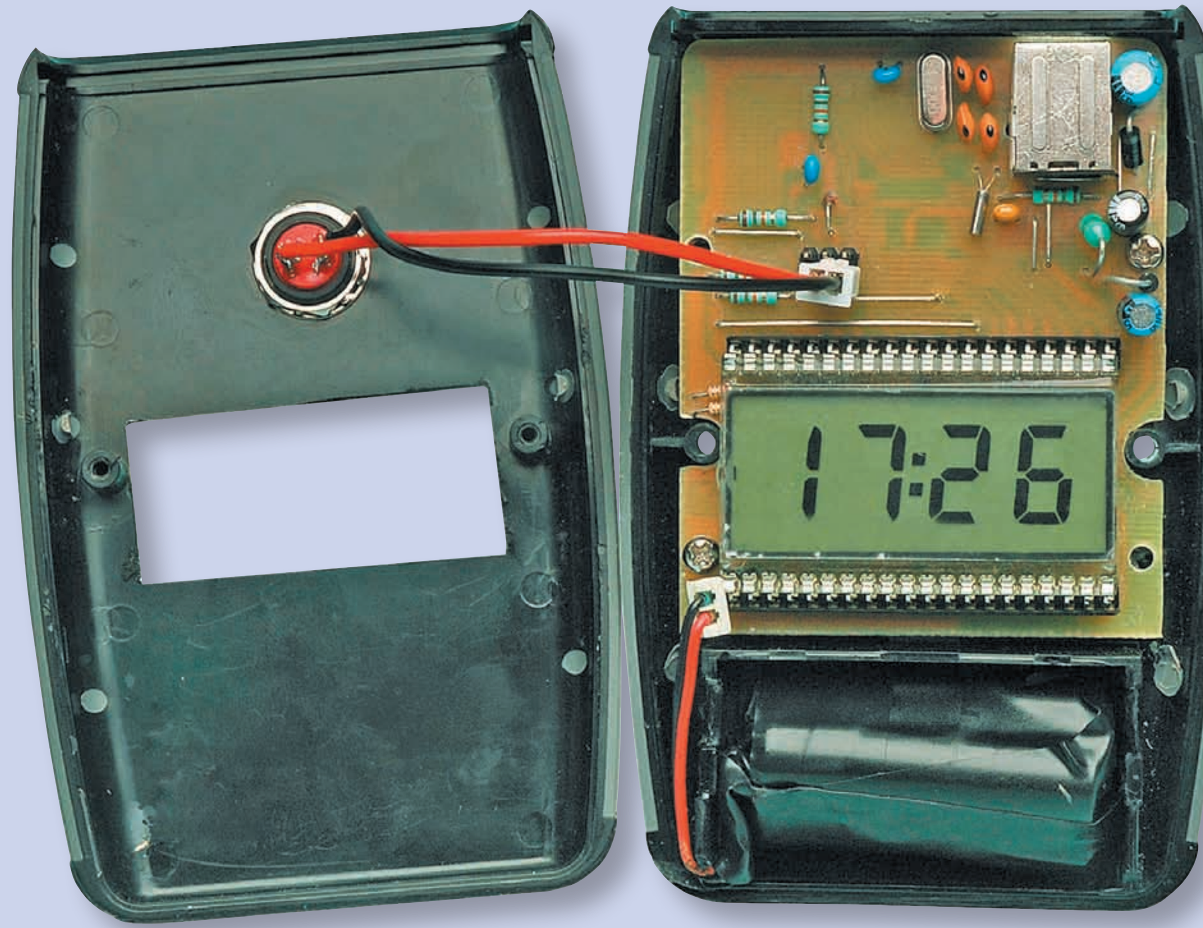
The modified socket strip can now be soldered into place. We also suggest adding a couple of foam pads, as shown in one of the photos, to provide additional support for the backlight module.

Once these socket strips are in place, install the USB socket and the 6-pin and 2-pin headers (CON1 and CON2).

That completes the top of the PC board, apart from plugging in the backlight module and the LCD. Leave these two components out for the time being. They go in after the four SMD ICs have been installed.

Soldering the SMD ICs

The four SMD ICs (IC1 to IC4) are installed on the copper side of the PC board – see Fig.2. To install them, you will need a soldering iron with a fine-pointed tip, some very fine resin-cored solder, a pair of self-closing tweezers and good light.



This life-size view shows the completed unit before the lid is fastened into place. Take care to ensure that the LCD is the right way round and be sure to install the battery with the correct polarity.

A magnifying lamp is also handy, or failing that, a magnifying glass so that you can inspect the soldered leads for possible shorts.

Begin by installing IC2 and IC3, the two 74HC573D latches. These have a larger pin spacing than IC1, and so are a good place to start.

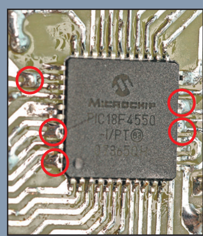
First, position IC2 on the PC board and 'clamp' it in place using the self-closing tweezers (or a clothes peg). Check that it is correctly oriented (ie, with pin 1 positioned as shown on Fig.2), then carefully solder pin 10 to its pad.

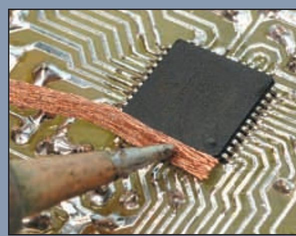
Now do the same for pin 20, which is diagonally opposite. The IC will now be firmly anchored in place and you can remove the tweezers and carefully solder the remaining 18 pins.

Repeat this procedure for IC3, then move on to IC1 (PIC microcontroller).

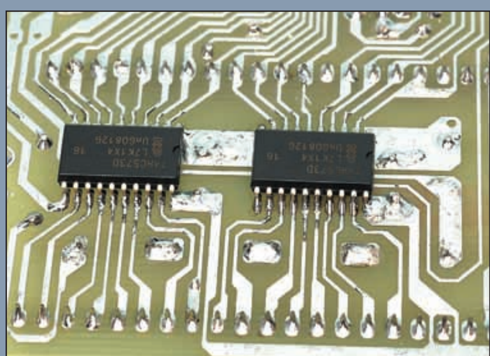
IC1 is slightly more difficult to install because its pins are closer together. As before, take care to ensure that it is properly oriented and clamp it accurately in position before soldering its pins.

Soldering In The Surface-Mount ICs





The PIC microcontroller (IC1) is mounted by soldering pins 21 and 22 (top-right of IC1) first. Any solder bridges between pins (eg, as indicated by the red circles in the centre photo) can be cleared using solder wick.



The photo on the left shows IC3 and IC4 mounted in position, while above is a close-up of IC4. Make sure that all ICs are correctly oriented.

Parts List – USB Clock with LCD Readout

1 PC board, code 779, available from the *EPE PCB Service*, size, 63mm × 78mm
1 Type B USB socket (Jaycar PS-0920)
1 Handheld case, size, 79mm × 117mm × 24mm, with battery compartment
1 transreflective 4-digit + colon LCD (Farnell 1989340)*, OR
1 reflective 4-digit + colon LCD (Jaycar ZD-1886)
1 20MHz crystal, HC49US case (X1)
1 32.768kHz watch crystal, ±20ppm (X2)
1 SPST momentary pushbutton switch (S1)
1 3.3μH RF Choke (Jaycar LF-1516)*
2 40-pin DIL IC sockets
1 6-way header, 2.54mm pitch (CON1)
1 2-way header, 2.54mm pitch (CON2)
3 900mAh (or better) NiMH AAA rechargeable batteries with solder tabs (Jaycar SB-1724)
1 50mm dia. × 300mm length of Thermotite heatshrink, for battery pack
1 Type A to Type B USB cable (Jaycar WC-7700)
2 header plugs (2.5mm pitch)
1 120mm-length of medium-duty hookup wire (red)
1 120mm-length of medium-duty hookup wire (black)
1 30mm length of 0.7mm tinned copper wire
4 6g self-tapping screws

Semiconductors
1 PIC18F4550-I/PT microcontroller (TQFP44 package) (IC1) (Farnell 9321365 – NOT programmed)
2 74HC573D octal D-type transparent latch (SO20 package) (IC2-IC3) (Farnell 1201326)
1 LM3519MK-20 LED driver IC (SOT-23 6 package) (IC4) (Farnell 1312717)*
1 LTR24S360-4YG LED backlight module (Farnell 1208878)*
1 1N4004 diode (D1)
1 1N4148 signal diode (D2)
1 1N5819 Schottky diode (D3)*

Capacitors
1 47μF 16V radial electrolytic
1 22μF 25V radial electrolytic*
1 4.7μF 16V radial electrolytic*
1 220nF monolithic
4 100nF monolithic
2 22pF ceramic
2 15pF ceramic

Resistors (0.25W, 1%)
4 15kΩ
2 3.3Ω
1 15kΩ*

Footnote
Parts marked with an asterisk (*) are required for optional LCD backlighting only.

In this case, the best pins to solder first are pins 21 and 22 at top right (see photo). These are soldered to the same pad, so they're easier to deal with. After that, solder pin 1, then remove the clamp and solder the remaining pins.

The trick here is not to apply too much solder. Use it sparingly and be sure to solder each pin quickly. You don't want to apply too much heat for too long, otherwise you could damage the IC. Don't worry if you get solder bridges between adjacent pins at this stage – just move onto the next pin and keep going.

After you've finished soldering the 44 pins, you can remove any solder bridges using solder wick braid. This is done by laying the wick along the pins and then applying the soldering iron to the wick to 'suck' up the excess solder (see photo).

IC4 (LM3519) can now be installed. It's quite small and comes in a 6-pin SOT-23 package. Once again, make sure it is correctly oriented before soldering its pins. Pin 1 is adjacent to the chamfer along one edge of its body (see Fig.2).

In practice, it's easiest to solder pin 6 first, since its PC pad is larger than the others. The remaining five pins can then be carefully soldered.

Now carefully inspect each IC with a magnifying glass to make sure that everything is correct. In particular, look for solder bridges and for pins that haven't been soldered.

Note: for further information on soldering SMDs, refer to the feature article which appeared in the July 2010 issue of *EPE* (photocopies only).

LCD and backlight installation

Now that the ICs are all in place, install the backlight module into its IC socket strip, then fit the LCD module. Take care with the orientation of the LCD – pin 1 goes to bottom left.

Making the battery pack

The battery pack consists of three NiMH AAA cells with solder tabs. These are connected in series, as shown in Fig.5 to give an output of 3.6V.

To make up the pack, first lay two batteries together side-by-side but facing in opposite directions. Solder their tabs together, then sit the third battery in the channel formed by the first two and solder its tabs.

It's then just a matter of adding the output leads (red for positive, black for negative) and using some heatshrink to secure the cells into a pack. The output leads are terminated in a 2-pin header and this should be fitted *before* the leads are connected to the battery. **Warning: be careful not to short any of the cell terminals or the output leads. NiMH batteries can supply lots of current.**

Final assembly

The assembly can now be completed by installing it in the specified case.

As shown in the photos, the PC board is secured to integral stand-offs in the bottom of the case using four 6g self-tapping screws. The battery sits in a separate compartment and is plugged into CON2, but don't do that just yet.

Next, you will have to drill a hole in the lid of the case for the switch, and cut out a window for the LCD. The full-size front panel artwork is shown in Fig.6. You can, if you wish, make two photocopies of this artwork – one for a drilling plate, the other for a front panel label.

Once you have copied Fig.6, attach a copy to the front panel (lid) using double-sided tape, then drill the hole for the switch. Use a small pilot drill to begin with, then carefully enlarge it to 10mm diameter using a tapered reamer.

The window for the LCD is best made by drilling a series of holes around the inside perimeter. The centre-piece is then cut out using a small hacksaw, and the job is then filed to a smooth finish.

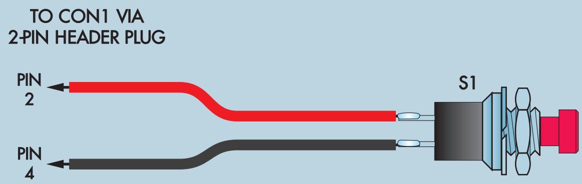


Fig.4: switch S1 connects to pins 2 and 4 of CON1 via a 2-pin header plug.

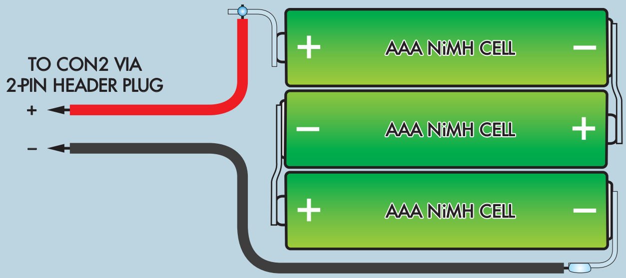


Fig.5: the battery pack is made up by connecting the NiMH cells in series. Use heatshrink sleeving to secure the cells together in one pack.

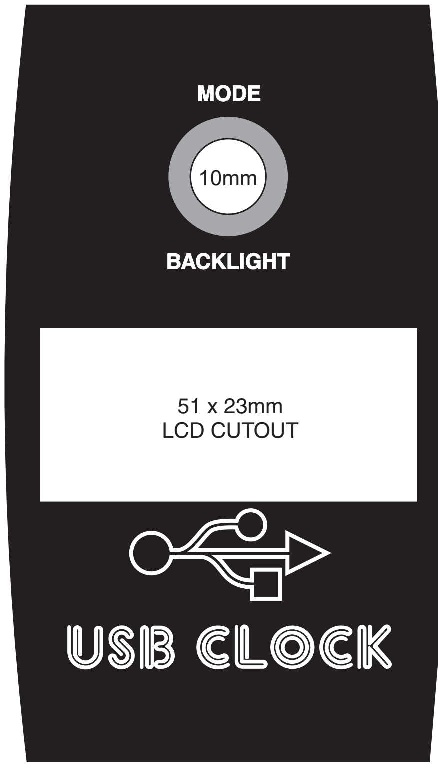


Fig.6: this full-size artwork can be used as a drilling template.

The drilling template should now be removed and a new front-panel artwork can be attached to the drilled panel. It can be affixed using double-sided tape or by using a thin smear of silicone sealant. The label should be protected by covering it with some wide strips of clear adhesive tape before cutting it out and attaching it to the front panel. .

Cut out the holes in the front panel label using a sharp hobby knife, then mount the switch in position and attach a couple of 100mm-long flying leads. These leads are then terminated in a 2-way header, which is then plugged into pins 2 and 4 of CON1.

Testing

Assuming IC1 is programmed, apply power by plugging the battery pack into CON2. **Be sure to connect the battery the right way round, as there is no on-board protection against a reversed battery connection.**

As soon as you apply power, the LCD should show a default time of **12:00**, assuming that the battery is charged. If the battery isn't charged, then you will have to apply power by plugging the USB Clock into the USB port of your PC.

The clock should then briefly flash the word 'SYnc' and then repeat this every 15 seconds, indicating that it hasn't been synchronised. If it does that, then it is working correctly and the lid can be attached.

It's now simply a matter of installing a driver plus the **usbclock.exe** program on your PC and then running the program to synchronise the USB Clock. We'll describe just how this is done in Part 2 next month. We'll also show you how to synchronise your PC to an internet time server and describe how to run **usbclock.exe** automatically each time your PC starts.

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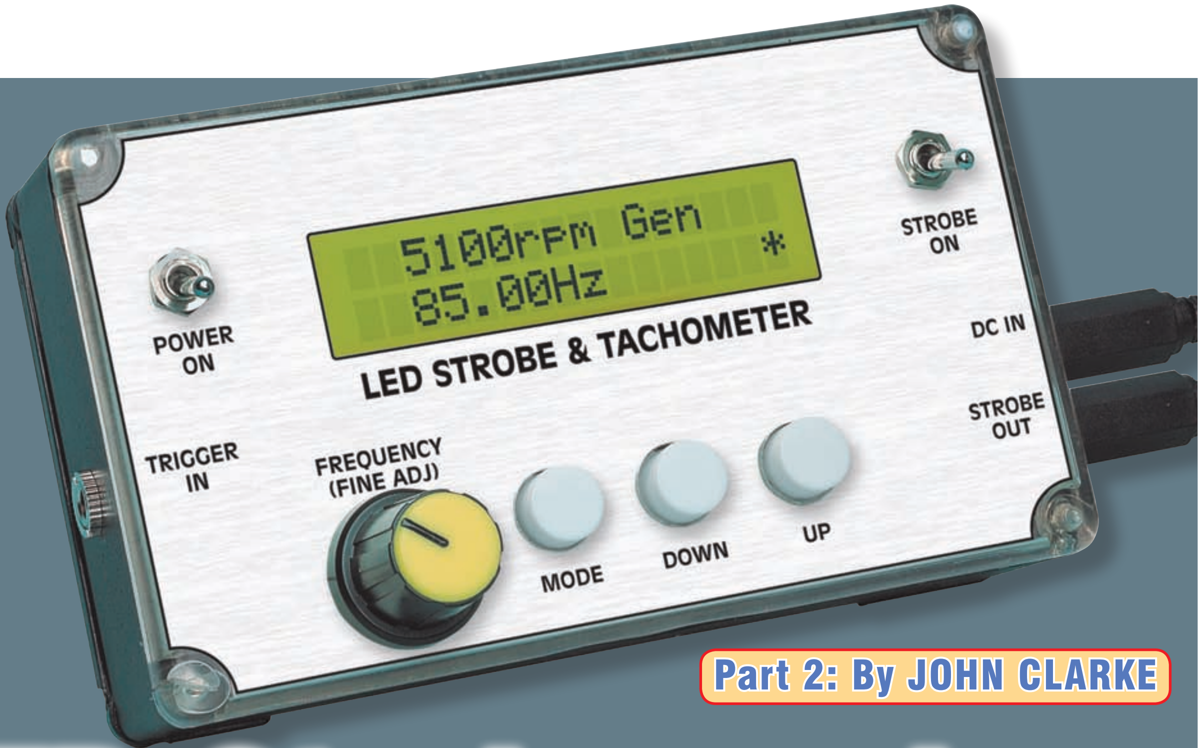


Part 2: By JOHN CLARKE

LED Strobe and Tachometer

Last month, we published the circuit of our new LED Strobe and Tachometer, and showed how to build the main unit and the strobe light. This month, we describe the assembly of the optional Photo-Interruptor and IR Reflector Amplifier boards. We also describe how the unit is used.

LET'S start with the assembly of the Photo-Interruptor board – see Fig.11. This board is coded 777 (Inter.) and carries just the photo-interruptor itself, a 150Ω resistor and three PC stakes. This board is available from the *EPE PCB Service*.

The assembly should take only a few minutes. Just be sure to install the photo-interruptor with the correct orientation, ie, with its diode symbol (indicated in blue on Fig.11) on the righthand side. It should be secured to the PC board using two M3 × 6mm screws and nuts before the leads are soldered.

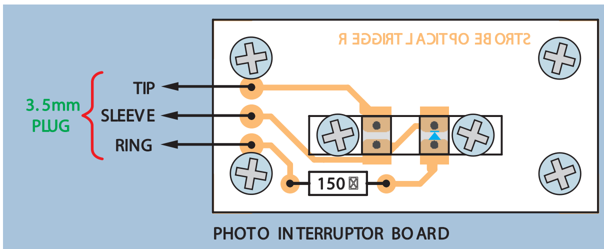
The completed assembly is wired to a 3.5mm jack plug using 2-core shielded cable, with the shield wire used as the 0V (GND) connection (ie, it goes to the sleeve) – see Fig.6 in Part 1 last month. Make sure that the tip and ring connections are made correctly. The tip connection is right at the end of the plug, while the ring is the separate section just behind the tip.

The 0V or ground terminal is the main body connection. Use your multimeter to identify the jack plug terminals if you are unsure.

Interrupt test

To test the unit, plug it into the main unit, apply power, set the unit to Trigger mode and then return to the main RPM display. If a slotted disc (or some other opaque shape) is now rotated through the photo-interruptor, a reading should appear on the display. In addition, the strobe should flash each time the light path is interrupted. If this doesn't happen, check your connections.

In practice, this unit is intended to be used with a small slotted disc (see photo) that spins within the gap of the photo-interruptor (ie, the disc is driven



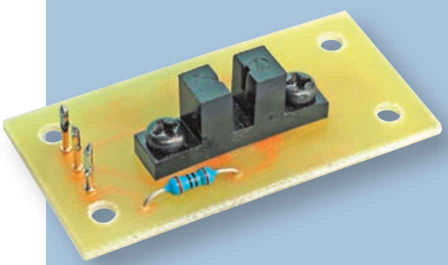
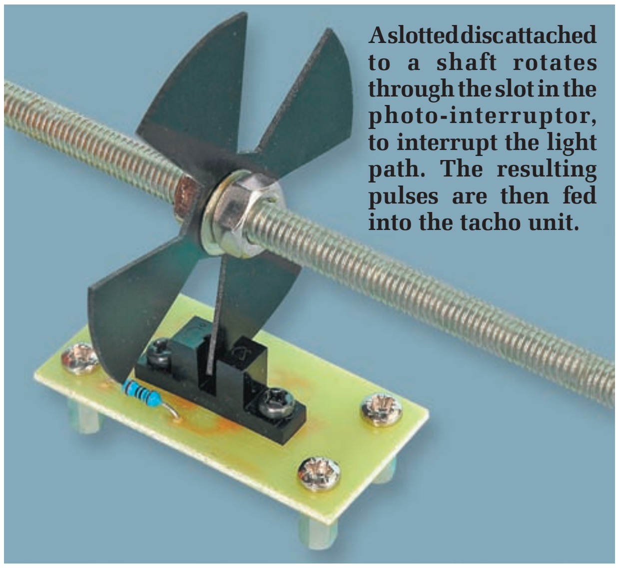


Fig.11 (above): make sure you get the photo-interruptor the right way round when building the photo-interruptor board (ie, diode symbol to the right). The PC board is mounted on nylon standoffs, to avoid shorting the tracks.



A slotted disc attached to a shaft rotates through the slot in the photo-interruptor, to interrupt the light path. The resulting pulses are then fed into the tacho unit.

by the rotating machinery). You will need to manufacture the disc to suit your application.

The completed Photo-Interruptor board can be attached to a fixed section of the machine. It is important to mount it using nylon (not metal) spacers at the output end, to prevent shorts to the soldered joints.

IR Reflector Amplifier

The IR Reflector Amplifier circuit is built on a PC board coded 778 (Reflect) and measuring 53mm × 32mm. This is housed in a plastic utility box measuring 82mm × 53mm × 31mm.

Fig.12 shows the assembly details. Begin by installing the resistors. Follow these with IC2, making sure it goes in with the correct orientation, then install the three electrolytic capacitors. Be sure to mount these capacitors with the correct polarity.

Finally, complete the board assembly by installing the three PC stakes, the infrared LED (IRLED1) and the infrared photodiode (IRSENS1). Note that IRLED1 is mounted at full lead length, so that it can later be bent over horizontally to protrude through the side of the box. Take care with the orientation of both these parts.

An accompanying photo shows how the board is mounted in its plastic case. It sits on four M3 × 6mm tapped nylon spacers, and is secured using M3 × 12mm countersink nylon screws and M3 nuts.

Two holes are drilled in one end of the box for the IR LED and photodiode, while another hole is drilled at the other end of the box to accept a cable gland.

As before, the PC board is wired to a 3.5mm jack plug using 2-core shielded cable, with the earth shield used as the 0V (GND) connection – see Fig.7 last month. Once again, make sure you get the tip and ring connections correct.

Testing the IR reflector board

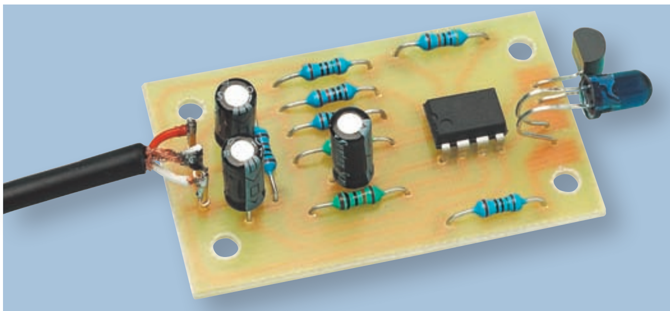
Having completed the assembly, the next step is to test the IR Reflector Amplifier for correct operation. To do this, first plug it into the trigger input of the LED Strobe and Tachometer unit, then set the Trigger mode and return to the main RPM display.

Now wave your hand in front of the sensor end of the IR Reflector box and check that the LCD shows an RPM reading. If this doesn't happen, then you need to check your wiring connections.

Note that as well as picking up reflected signals from IRLED1, the circuit will also detect signals from other infrared sources, such as incandescent lights running on the 50Hz mains. This means that RPM measurements are best done in natural light or subdued light.

Measuring the RPM of a machine should be done with the sensor about 30mm to 40mm away from the rotating shaft or fan. This means that you *must* exercise a great deal of caution, to ensure that neither the sensor or any part of your body touches any moving parts. In complex situations, the best approach may be to mount this sensor unit in a fixed position before switching the machine on. In short, use your common sense.

Note that as well as displaying the RPM value, the LCD also indicates



The IR reflector amplifier board must also be mounted on nylon spacers, to avoid shorting tracks.

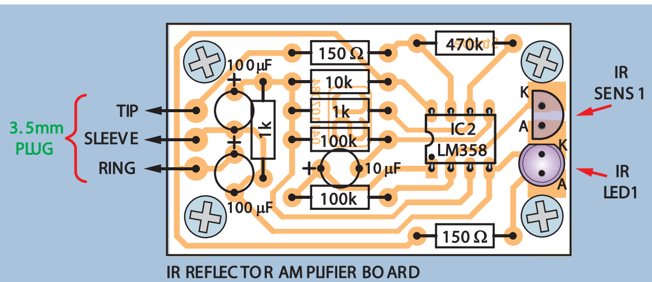


Fig.12: follow this diagram to build the IR reflector amplifier. Take care to ensure that IR SENS1 and IR LED1 are installed with the correct polarity.

Using white LEDs as strobes: busting a myth

BEFORE attempting to use a white LED as a strobe we had to be sure of its suitability. Initially, we had our doubts because we had read somewhere that white LEDs cannot be strobed at a fast rate. The reason given was that unlike coloured LEDs, white LEDs contain a phosphor and the persistence of this phosphor prevents them from switching on and off at a fast rate.

One of the reasons behind this story is that most of the phosphors we are familiar with do have long persistence. These include those used in toys that glow for hours after being exposed to light, and in fluorescent lights that continue to glow for a short time after being switched off. Similarly, some white LEDs do glow for a short period after the power is switched off.

In this case, we wanted to use a Luxeon white LED as a strobe for this project, so we set out to test its suitability. First, we checked the manufacturer's data sheet, and this specified less than 100ns for both the turn-on and turn-off periods.

From this, it is clear that white Luxeon LEDs do indeed switch on and off very quickly and so would be quite suitable for our proposed strobe.

How they're made

Further research on the web revealed that there are several ways in which white LEDs can be made. One way is to use red, green and blue LED chips and mix their outputs together to produce white light. These have a fast response because no phosphor is involved in converting the colour.

Another way to achieve white light is to use a phosphor that converts the emission from a single colour LED into a white spectrum. There are two types, one based on a blue LED and the other on a near-ultraviolet LED.

The blue-LED-based white LEDs use a phosphor that adds in colours toward the yellow end of the spectrum so that the combination of the blue light and the phosphor emission produces a white light. This construction is the most common form used for white LEDs. However, the phosphor used does not phosphoresce but emits light by a process called 'scintillation', an effect that has no light persistence.

The alternative white LED construction is not so common and is based on a near-UV LED and a mixture of a red and blue emitting phosphors, plus a green emitting copper and aluminium-doped zinc sulphide. The emission works in a similar manner to fluorescent lights. We do not have any information about the response time for these LED types, but presumably these do have a long persistence.

For our strobe, we use the more common blue-LED-based white LED. This type is manufactured by Luxeon, Cree and several others.

Measuring the response time

To further assess its suitability, we decided to measure the response time of a 1W Luxeon white LED. This was done using a phototransistor to detect the white light, as shown in Fig.13.

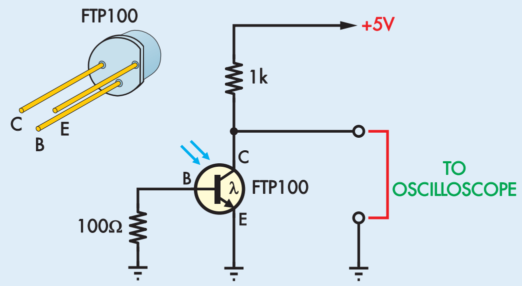


Fig.13: this simple phototransistor circuit was used to measure the response time of the white LED used in the strobe.

This circuit uses a low-value (1kΩ) collector (C) resistor to ensure that the phototransistor switches on quickly. In addition, the 100Ω resistor from base (B) to ground ensures that the phototransistor quickly switches off in the absence of light.

By pulsing the LED and monitoring this on one channel of a 200MHz oscilloscope, we could measure the response at the collector of the phototransistor on the second channel of the oscilloscope. We measured the rise-time for both a 1W white Luxeon and a Cree XR-C white LED from 10% to 90% full brightness to be just 290ns, which is really quite fast. The 'fall-time' response from 90% to 10% brightness was 360ns.

Next, we wanted to make sure that we were measuring the response time of the phosphor rather than the light from the blue LED itself. To do this, we placed a Polaroid red circular polarising filter over the white LED to block the blue spectrum from the phototransistor. When we did this, the response times remained the same, although the amount of light available for the measurement diminished markedly.

This all means that the white LED response is very likely to be better than 100ns, just as the manufacturers claim. The slower response times we measured are actually the phototransistor response times – **ie, the phototransistor is slower than the white LED.**

From this, it is clear that the 1W white LEDs specified are more than fast enough for strobe applications. However, one question remains: if white LEDs do have a fast response, why do some continue to glow for a short time after the power is switched off?

The main reason is because they are often driven by a supply with a filter capacitor, and it takes time for the filter capacitor to discharge after switch off.

rotation by displaying an Up or Down arrow that flashes on and off. Note also, that it may be necessary to average the readings to account for slight speed variations while the machine is running.

Using the strobe/tacho unit

Each time you switch it on, the strobe/tacho unit shows the main readout on the LCD. This will either be in Generator mode or Triggered mode, depending on the last selection.

In Triggered mode, the LCD shows the RPM on the top line, then the word 'Trig' and either an Up or Down arrow if there are incoming trigger signals from an external sensor. This arrow will flash on and off, with an Up arrow displayed when rising-edge triggering is selected and a Down arrow when falling-edge triggering is selected.

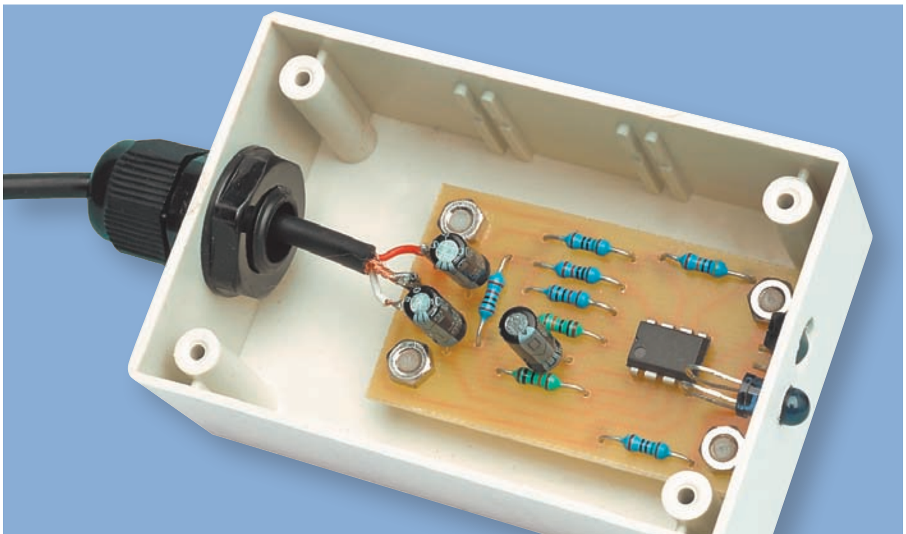
The second line shows the frequency in Hz and following that the division ratio (ie, 0.5 and 1 to 8). An asterisk (*) on the far right-hand side is displayed whenever the strobe is flashing correctly, but is not displayed

when the strobe LED is continuously lit (as happens when the flash period is longer than the time between flashes).

In the Generator mode, the display shows the RPM in the top line, followed by the word 'Gen'. The second line shows the frequency in Hz. As before, an asterisk (*) is shown on the right-hand side when the strobe LED is flashing.

In this mode, RPM adjustments are made using the Up and Down switches and the fine adjust potentiometer (VR1). The Up and Down switches adjust RPM in 100 RPM steps, while the potentiometer adjusts in 1 RPM steps over a 100 RPM range.

Selection of either mode is made using the Mode switch. When pressed, the display shows 'Trig/Gen' on the top line and the selection (either 'Gen or Trig') on the second line. The selection is then made using the Up or Down switches.



The Infrared Reflector Amplifier board is mounted in a small plastic case. Note how the IR sensor and IR LED are arranged.

Options

When the Generator mode is selected, a further press of the Mode switch brings up the 'Flash Mode' option. This can be set to either 'Automatic' or 'Fixed' using the Up and Down switches.

Pressing the Mode switch again brings up the 'Flash Period' setting. If the 'Fixed' mode is selected, the period can be adjusted from 32μs to 6.5ms, in 25.4μs steps. The display shows the value in 'μs' for readings less than 1000μs (1ms) and in '*ms*' for readings above 1ms.

Note that because the flash period is fixed, it is possible for the frequency of the RPM signal to be high enough for the LED to stay fully lit (as indicated earlier), ie, when the unit is flashed at a faster rate than the update period.

Correct operation is indicated by an asterisk (*) at the lower right-hand side of the LCD. When the asterisk appears, the strobe is flashing. Conversely, if the strobe is lit continuously, the asterisk is off.

If the Automatic mode is selected, then the display will show the automatic percentage value from 1% to 10% (ie, this is the strobe's duty cycle). This value is altered using the Up and Down buttons.

Pressing the Mode switch again returns the unit to the main tachometer display mode (showing RPM and frequency).

Trigger mode

The Trigger mode allows even more selections. These are Edge, Division, Flash Mode, Flash Period and Averaging (of the reading). As before, these are selected using the Mode switch.

First, the trigger edge can be set to either rising or falling. In this case, the LCD shows 'Edge' on the top line, while the second line shows either 'Rising' followed by an Up arrow or 'Falling', followed by a Down arrow (depending on the selection). The Up and Down switches allow the setting to be changed.

The Division selection allows the number of incoming trigger pulses to be divided by a set value, to give the correct reading on the LCD. When this is selected, the top line shows the word 'Division', while the second line shows the divide-by value. Division values of 0.5 and from 1-8 are available, and are again selected using the Up and Down switches.

For example, if you wanted to use the IR reflector sensor to measure the rotational speed of a three-blade fan, the division value would be set to three.

The Flash Mode and Flash Period settings are adjusted in the same way as the Generator mode. The Averaging mode is included to smooth out irregular measurements on a machine that is not running smoothly. You can average over 1 to 10 measurements and this is set using the Up and Down buttons. Higher averaging may be useful when the measured machine rotation varies markedly.

Finally, when the main RPM and frequency reading is displayed, the strobe firing position can be altered using the Up or Down switches. Note that this feature is available only when the division is set to two or more.

Using a Hall effect sensor

If you wish, you can use a Hall effect trigger instead of the photo-interruptor. As with the latter, this can be wired directly to the tachometer unit using 2-core shielded cable and a stereo 3.5mm jack plug.

Note that the supply for the Hall effect sensor connects between the ring (+5V) and the ground 0V. The tip connection is for the Hall effect sensor's output signal. ***EPE***

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Warning!

Flashing lights, particularly in the lower frequency range from about 5Hz (300 RPM) and upward can induce seizures in people subject to photosensitive epilepsy. Flashing lights can also trigger a migraine attack. It is recommended that people prone to these effects avoid stroboscopic lights.

Take Good Care Of Yourself

TechnoTalk

Mark Nelson

So sang The Three Degrees, and Mark reckons it's not a bad policy for us too. Here's an assortment of news items from recent months that tend to support this guiding principle.

Taking care of yourself includes avoiding risks with electronics, and while you face few risks assembling hobby projects, that's not the case when your creations eventually go to landfill. Not your problem? Well, that's not what the authorities think, and since 2006, regulations have been in force to restrict the use of hazardous substances. Known as the RoHS regs, their proper name is the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2008. The UK government website is at **www.rohs.gov.uk** and all of the major electronic component distributors provide information as well.

Farnell, for instance, has revised its *RoHS Directive Technical Guide* to bring readers fully up to date. Hobbyists are not bound by the regulations (yet!) if they assemble projects for their own use. However, if you are a freelance designer and develop projects for commercial clients then you need to understand the regulations, including the exemptions that used to exist but which have now been revoked.

The company has done an excellent job with this illustrated guide, which is actually quite interesting to read, especially if you wish to know about dendrites, tombstoning and the popcorn effect. There is also a revealing section on how to troubleshoot negative reliability issues with lead-free solder. You can download it at: **http://tinyurl.com/2wnsmxm**

PVC to be banned?

Future RoHS regulations are likely to restrict the use of more materials, and some will be banned in electronics products. Green groups have been agitating for the plastic PVC, used for 70 years or more to insulate wires and cables, to be banned, and at one stage the European Parliament looked likely to sanction this.

Uncontrolled burning of devices containing PVC and other chlorinated or brominated flame retardants releases very toxic and carcinogenic dioxins, which is a significant problem in developing countries where electronic waste is routinely burned in open fires. European manufacturers argue that developing alternatives to these products would cost a fortune and banning them in Europe alone would not protect people in other continents.

Although RoHS is itself a European initiative, there are comparable activities in Asia. The Chinese government has had its own RoHS scheme in place since 2007, and while there are no restrictions on substances in Japan, most domestic and commercial products that contain potentially harmful substances must be marked clearly under what is called J-Moss (Japan Ministerial Ordinances). Conveniently for international trade, the substances and maximum concentration values are the same as in Europe, and this requirement came into force on 1 July 2006, the same day as European RoHS.

Weren't me, guv…

The newspapers have been full of reports about criminals who deliberately stage road accidents and submit false claims for compensation. There was better news in August, when thirteen people were sentenced after an investigation into the gang's unwelcome activities. Equally pleasant to read was the good news that an impending insurance claim against an innocent van driver was dropped after his employer's onboard vehicle tracking system proved he could not have been involved.

In this triumph of electronic technology, a heating engineer was accused of driving at an excessive speed and colliding with a driver on a country road near Exeter, smashing his wing mirror. The employee disputed the allegation and was vindicated by the in-cab fleet management system that managing director Tim Ford had installed.

Explained Tim, 'We invested in Navman Wireless vehicle tracking three years ago, and so were in a position to discover which engineer was allegedly responsible and generate a report detailing his precise speed and location at the time of the purported incident. Our employee maintained he had pulled over, giving way to the other driver and that it was therefore not correct that he was travelling at speed. This was proven by consulting the data records, and when faced with the evidence, the accuser backed down.

All too often we find that easily identified liveried vehicles are blamed for collisions, as telephone numbers can be obtained and false claims made. We're delighted to have evidence available, at the touch of a button, via the fleet management system.'

Save your pennies

On a related theme, the world's global leader in satnav receiver sales warns that using your mobile phone satellite navigation for a journey abroad could cost twice as much as the fuel. Garmin found that using one of the most well known turn-by-turn navigation services on a mobile phone generated a bill of £36 in data roaming charges during the 185-mile journey from Calais to Paris – that's an eye-stinging 20 pence a mile.

Garmin's head of communications, Anthony Chmarny said: 'Using free satellite navigation isn't as free as it would like to make out, especially when you are using your mobile phone abroad. Many of the well known navigation products use the mobile phone network to download maps as they go, meaning people could end up with a nasty shock when their mobile phone bills arrive: the costs could be double that of the fuel used for the journey they were navigating.'

The only consolation for the unwary is that since the beginning of July, mobile phone users will be cut off automatically (unless they request otherwise) once they have spent 50 euros on data, although this could leave them in the absurd position that they get half way through a journey and no longer have access to navigation to complete it.

The advice from Garmin is to check whether your mobile phone application has maps included or if it relies on the mobile network to download maps (with the risk of incurring huge mobile bills). Of course, many standalone satnav devices have route data built in and some smartphones have on-board mapping, meaning they do not need to download data information.

A handy tip published in trade magazine *Land Mobile* is that the free Ovi Maps navigation software for Nokia smartphones includes an option to download mapping beforehand to the phone's memory card. This avoids the need to rely on data roaming altogether.

Finally

The assertion that mobile phones rot your brain has been dealt another blow by an announcement from the Institution of Engineering and Technology (IET), which is Europe's largest body of engineering and technology professionals. A new 'position statement' from its Biological Effects Policy Advisory Group states that, 'the overwhelming majority of the evidence does not indicate that normal exposure to low-level electromagnetic fields has harmful health effects and there is no persuasive evidence that normal mobile phone usage, or exposure to pylons and power lines, causes harmful health effects such as cancer.'

IET fellow Prof. Tony Barker sums up: 'The absence of robust new evidence of harmful health effects in the past two years is reassuring and is consistent with findings over the last two decades.'

Whether this will pacify the angry brigade who demand full mobile coverage wherever they roam, but oppose new base stations remains to be seen.

By JOHN CLARKE

Microphone preamp for PCs and MP3 players

Want to connect a professional microphone with balanced outputs to the line input of your PC's soundcard or an MP3 player for high-quality voice recordings? This microphone preamp circuit lets you do just that. It features a balanced input, has a clipping indicator LED and can be powered from a USB port or from an external DC source.

ALTHOUGH most PCs have a microphone input for recording, these inputs are for basic electret microphone types only. Electret microphones are typically used in headsets and are generally of low quality.

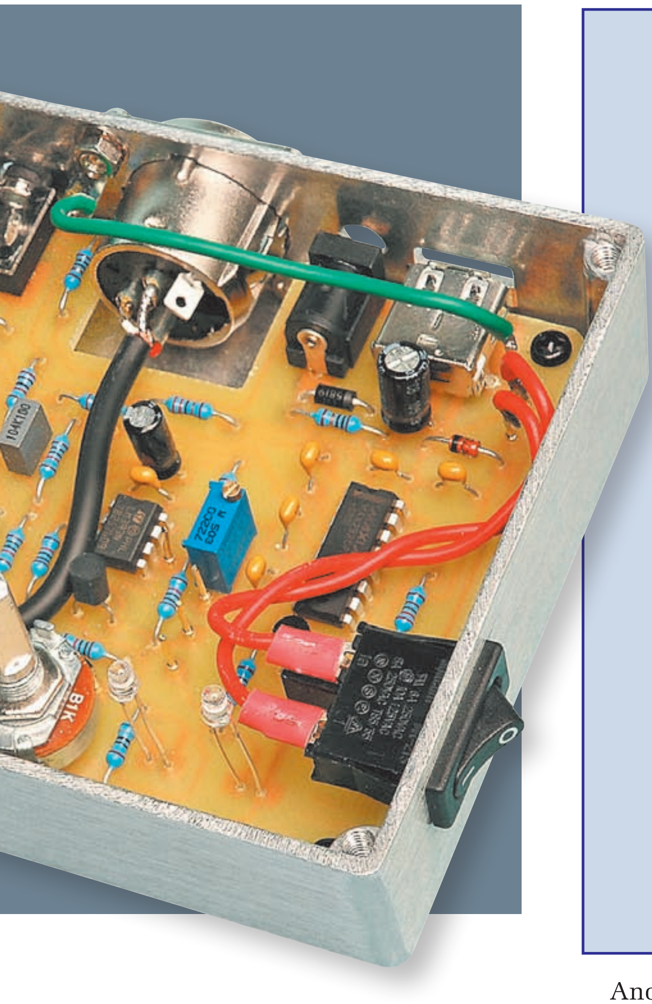
Similarly, some MP3 players include an internal electret microphone for recording, but again, the quality is limited. These players often also include a line input, to accept external audio signals.

Using an electret microphone will generally be satisfactory for recording brief announcements and reminders. However, if you want really good sound quality, a professional microphone will be required. This type of microphone will also be necessary when the microphone needs to be more than just a metre or two away from the computer or MP3 player.

Why are they better

So why do the professional microphones give better sound than low-cost electret microphones? There are several reasons.

First, professional microphones use a high-quality microphone element



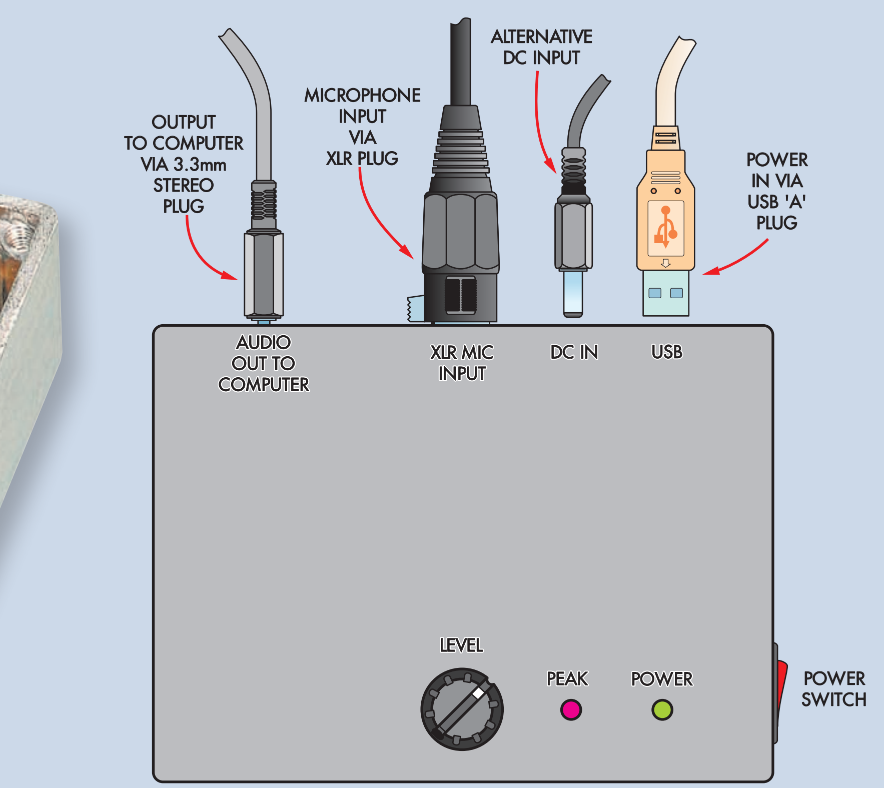


Fig.1: this diagram shows how the Balanced Microphone Preamplifier is connected to a computer. Power can come either from a USB port or from an external DC plugpack supply (see text).

Main Features

- Balanced input
- Stereo output
- USB or plugpack powered
- Level control
- Peak indicator
- Line level output

that has a smooth frequency response, plus low noise and low distortion. Typical low-cost electrets do not have a smooth frequency response, but a response that peaks around the mid audio frequencies. And while low-cost electret microphones readily detect handling and breathing noises, professional microphones are designed to minimise this problem.

Professional microphones also have a tailored pickup response that is more sensitive towards the front of the microphone than to the rear. This lack of sensitivity towards the rear helps prevent unwanted noise pickup.

Another advantage of professional microphones, particularly for voice recordings, is that they give more depth to the sound. That's because the bass response is more pronounced when the microphone is brought close to the mouth. A headset electret microphone, on the other hand, usually has a poor bass response.

Taken together, these refinements mean that a professional microphone will produce a recording that sounds far crisper and cleaner than one from an electret microphone – all without extraneous noises masking the wanted sound.

Of course, electret microphones are ideal for many applications. In fact, high-quality electret microphone inserts are often used in professional microphones and can produce excellent sound quality when placed inside a professional microphone housing. It's just that if you want high-quality recordings, a professional-quality microphone is the way to go.

Balanced outputs

While professional microphones can come in many forms (eg, dynamic and electret types), they all have one thing in common, and that

Specifications

Signal-to-noise ratio: 80dB with respect to 1V output and 50mV input and with 600Ω input loading impedance (this measurement includes a 20Hz to 22kHz bandpass filter).

Frequency response: within 0.25dB from 20Hz to 20kHz.

Total harmonic distortion: less than 0.01% at 1V output and 50mV input for all frequencies from 20Hz to 20kHz.

Signal handling: 2.8V RMS output

Sensitivity for 1V out: 9mV

Parts List – Balanced Microphone Pre-amp

1 PC board, code 780, available from the *EPE PCB Service*, size 102mm × 83mm
1 diecast aluminium box, size 119mm × 94mm × 34mm
1 3-pin small size female XLR panel socket
1 Type-A PC-mount USB socket
1 2.5mm PC-mount DC socket
1 3.5mm PC-mount stereo jack socket
1 Ultra-mini SPST rocker switch (S1)
1 knob to suit potentiometer
4 M3 tapped × 6.3mm standoffs
8 M3 × 5mm screws
2 M3 × 10mm screws
2 M3 nuts
4 M3 flat washers
1 solder lug
17 PC stakes
1 150mm length of red medium-duty hookup wire
1 75mm length of green medium-duty hookup wire
1 75mm length of 2-core shielded cable
1 25mm length of 6mm diameter heatshrink tubing
4 rubber feet

Semiconductors
2 TL072CP dual op amps (IC1,IC2)
1 LM393N dual comparator (IC3)
1 MAX232CPE RS232 line driver (IC4)
1 LM336-2.5 2.490V reference (REF1)
1 BC327 PNP transistor (Q1)
1 5.6V 1W Zener diode (ZD1)
1 1N5819 1A Schottky diode (D1)
1 3mm green LED (LED1)
1 3mm red LED (LED2)

Capacitors
1 100µF 25V PC electrolytic
2 22µF NP electrolytic
1 10µF 16V PC electrolytic
6 1µF monolithic ceramic
2 100nF MKT polyester
4 220pF ceramic
2 100pF ceramic

Resistors (0.25W 1%)

1 220kΩ	1 180Ω
3 100kΩ	2 150Ω
2 22kΩ	1 68Ω 1W (R1)
1 20kΩ	1 39Ω 1W (R1)
12 10kΩ	2 33Ω
1 2.2kΩ	1 10Ω
2 680Ω	1 10Ω (R1)

1 1kΩ 16mm linear pot (VR1)
1 50kΩ multi-turn top-adjust trimpot (VR2)

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is a balanced output. A balanced output provides two signals that are 180° out of phase with each other. These signals are fed out via a 3-pin XLR plug that connects to a matching 3-pin XLR socket on the microphone lead.

As a result, the two balanced microphone signals are fed down the microphone cable via separate leads. These leads are 'shielded' to help prevent them picking up noise and mains hum. In addition, this arrangement effectively removes any noise that is picked up when connected to a balanced input on an amplifier.

In operation

In operation, the balanced leads each pick up the same noise signals along the length of the microphone lead. That's because these leads are run very close to each other, often as a twisted pair. When fed into a balanced amplifier, the signal from each lead is subtracted and this removes the common noise signal in each lead (ie, the noise signals are cancelled out by the amplifier because they are in phase).

The wanted audio signals from each microphone lead are also subtracted, but because these are in anti-phase, the signal level is actually doubled as a result of the subtraction. This means that balanced microphone leads can be many metres long without any noticeable increase in noise pickup.

In addition, the output impedance of professional microphones is usually very low, and this also minimises noise pickup. Impedances are often well below the standard 600Ω, with some high-quality microphones having an output impedance as low as 150Ω.

Of course, a balanced amplifier is also required in order to use a balanced microphone, and this is always found on professional audio gear. We also published a *Balanced/Unbalanced Converter for Audio work* in the September 2010 issue of *EPE* (it can convert signals both ways).

In operation, the balanced amplifier correctly subtracts the balanced signals and provides the gain required to bring the signal level up to line levels. This means that the recording can be made using the line input rather than the microphone input at the computer. Alternatively, for an MP3 player, you can again use the line input and forget about the internal microphone.

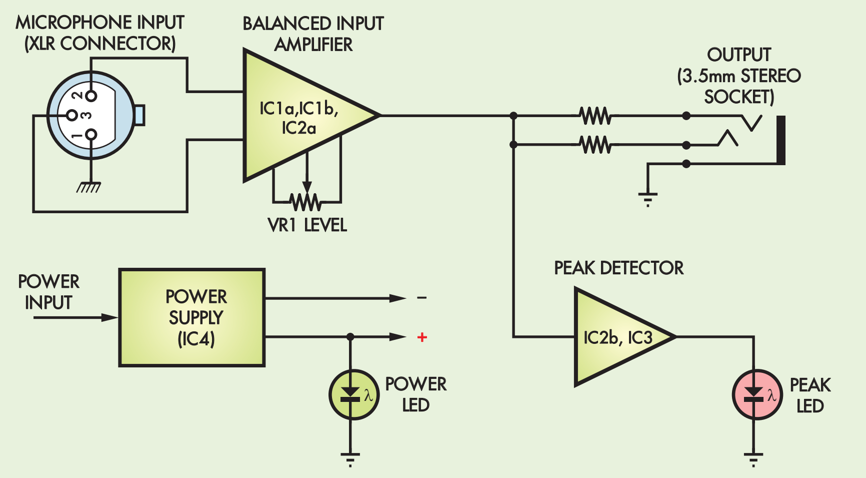
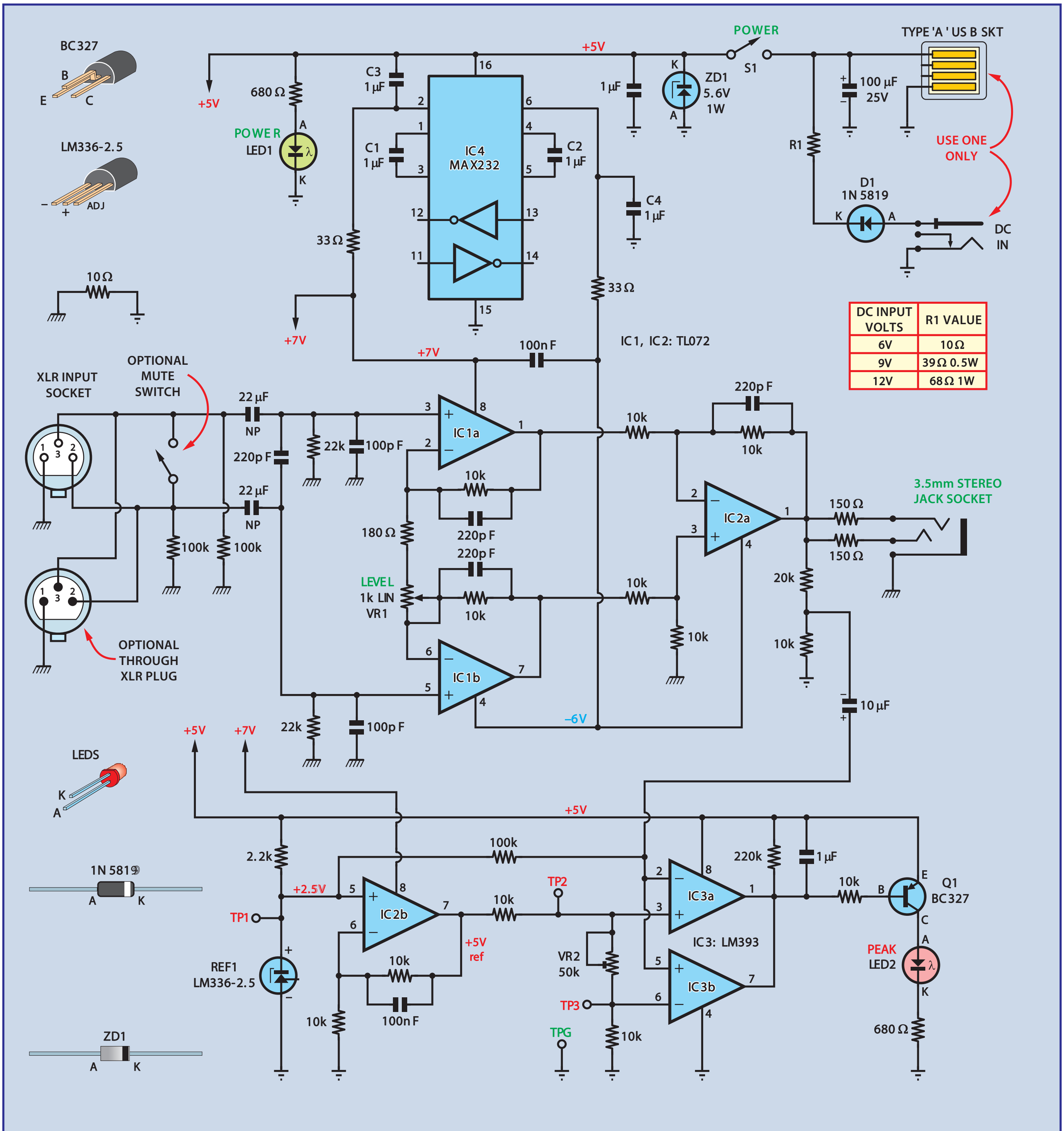


Fig.2: the block diagram of the Balanced Microphone Preamplifier. The balanced signals from the XLR socket are amplified by IC1a and IC1b and summed in IC2a to give an unbalanced output that is fed to the output socket. IC2b, IC3 and the associated LED provide peak level indication,



MICROPHONE PREAMP FOR COMPUTERS AND MP3 PLAYERS

Fig.3: the full circuit diagram. IC4 functions as a charge-pump converter to provide +7V and –6V supply rails for IC1 and IC2. IC1a and IC1b are wired as non-inverting amplifier stages, while IC2a sums their outputs. IC3a and IC3b function as a window comparator. They compare a sample of the output signal with reference voltages set by REF1, IC2b and VR2.

Recording at line levels also helps to minimise noise. That's because the signal does not have to pass through an internal preamplifier in the computer or MP3 player.

How it's connected

How the *EPE* Microphone Preamplifier is connected to a computer is shown in Fig.1. It includes the 3-pin XLR connection for the microphone lead and a stereo 3.5mm jack socket output. The connection is made to the computer using a 3.5mm stereo jack-to-jack lead or a 3.5mm stereo jack to phono plug lead if the computer has phono inputs.

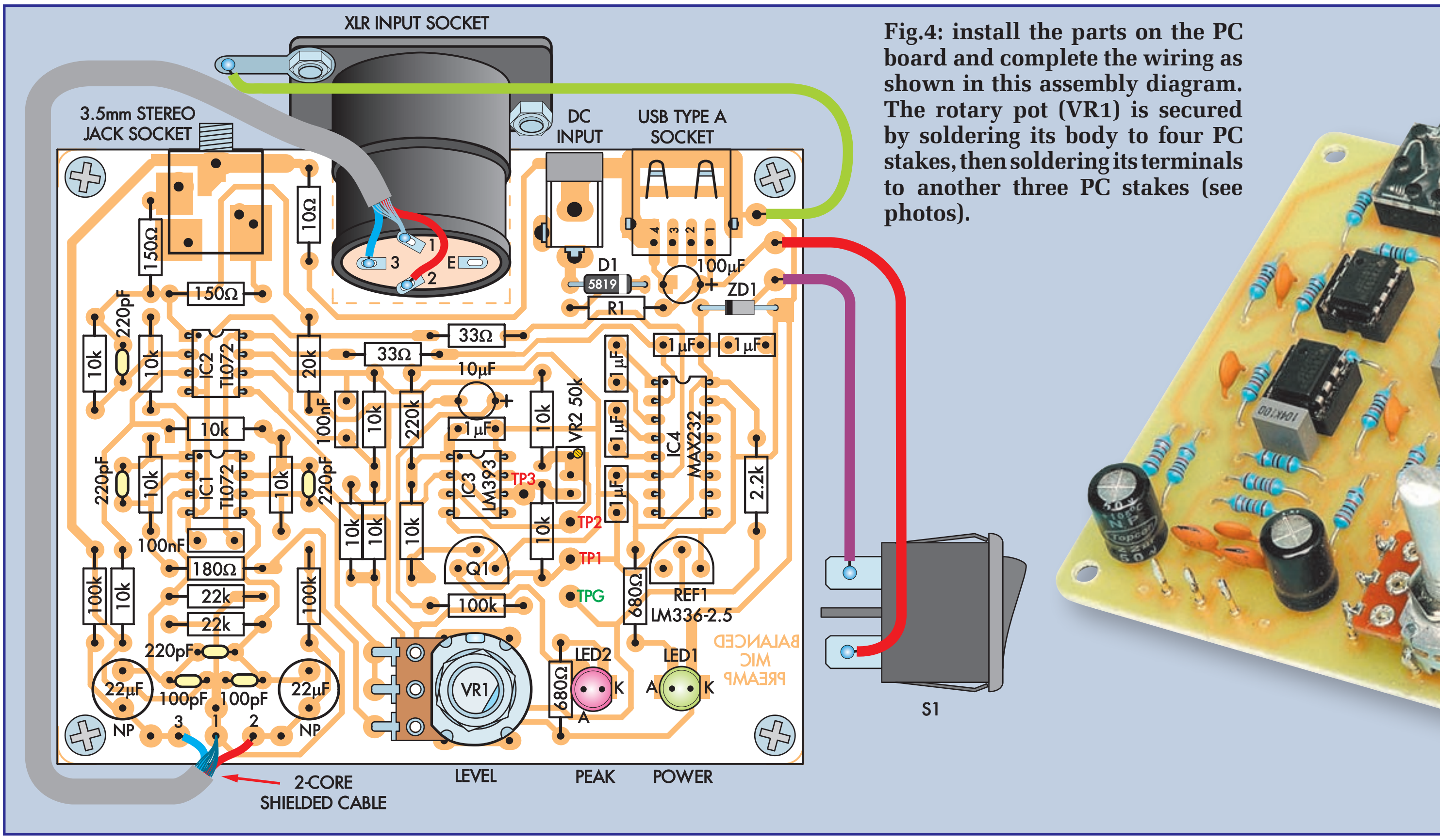


Fig.4: install the parts on the PC board and complete the wiring as shown in this assembly diagram. The rotary pot (VR1) is secured by soldering its body to four PC stakes, then soldering its terminals to another three PC stakes (see photos).

Power for the unit can come from either a DC plugpack supply or from the computer's USB port. In the latter case, the USB port provides a +5V rail to the preamp via a standard 'A' Male to 'A' Male USB connector lead.

In operation, the preamp is switched on and off via a power switch on the side of the case and a 'Power' LED lights when the unit is on. The output signal level is adjusted using a pot (VR1) and a peak indicator LED lights when the signal exceeds line level.

If the peak indicator LED lights, then the signal level is too high. This will cause clipping and distortion in the recording. In practice, it's simply a matter of adjusting the level to avoid any peak indication during microphone use.

Fig.2 shows the block diagram of the Microphone Preamplifier. The balanced microphone signal is fed in via the XLR input socket, and the two anti-phase signals are then amplified by op amps IC1a and IC1b. The signals are then subtracted in IC2a and fed to the output stereo jack socket.

The peak detector circuit monitors the output signal level and flashes the Peak indicator LED when the signal exceeds the threshold level. This circuit comprises IC2b and IC3, plus the LED itself.

Circuit details

Refer now to Fig.3 for the complete circuit details.

As shown, the balanced input signals from the microphone are coupled in via 22µF non-polarised capacitors and fed to the non-inverting inputs of op amps IC1a and IC1b (pins 3 and 5). These input signal lines (ie, pins 2 and 3 on the XLR socket) are each tied to ground using a 100kΩ resistor, to prevent them from floating with no input connected.

The 220pF capacitor across the two inputs shunts radio frequencies, while the two 100pF capacitors at pins 3 and 5 also shunt RF signals to ground.

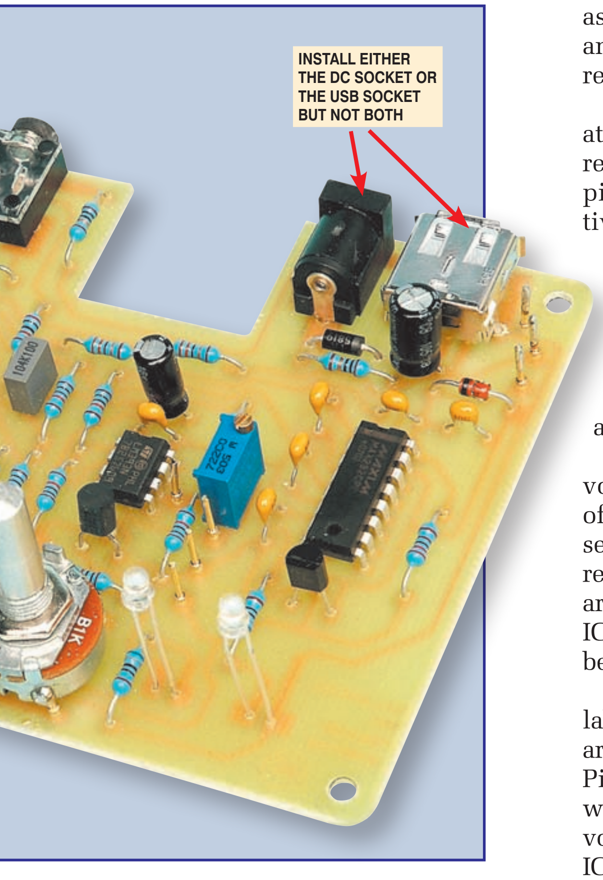
Pins 3 and 5 of the op amps are each tied to ground via a 22kΩ resistor, again to prevent spurious operation in the absence of an input signal. Note, the signal ground and supply ground are isolated in this part of the circuit to reduce earth loops, and this is the reason for the different earth symbols shown.

Op amp IC1a amplifies the pin 3 microphone signal, while IC1b amplifies the pin 2 signal. Both are configued as non-inverting amplifiers with 10kΩ feedback resistors, while a 180Ω resistor and a 1kΩ pot (VR1) are connected in series between their inverting inputs. The 220pF capacitors across the 10kΩ resistors roll off the high-frequency response above 70kHz.

The Level control, VR1, varies the gain of IC1a and IC1b between about 9 and 56. The outputs from these op amps appear at pins 1 and 7, and are summed in unity gain differential amplifier IC2a.

For signals coming from IC1a, IC2a functions as an inverting amplifier with a gain of –1, as set by its 10kΩ feedback resistors. However, for signals on its pin 3 input, IC2a operates as a non-inverting amplifier with a gain of 2. Because of this, the signal from IC1b is divided by two using a 10kΩ resistive divider before being applied to IC2a.

This means that each signal path from IC1a and IC1b has overall unity gain through IC2a. However, IC2a inverts the signals from IC1a, so that they are now in phase with the signals from IC1b. As a result, both signals add to provide an overall gain of 2 for the stage (ie, IC2a sums its two input signals).



The resulting unbalanced signal appears at pin 1 of IC2a and is fed to the left and right terminals of a 3.5mm stereo jack socket via 150Ω isolation resistors. The 220pF feedback capacitor across IC2a rolls off the high-frequency response of this stage.

Peak detector

IC2a's output also drives the peak detector circuit. This consists of op amps IC3a and IC3b, which are wired as a window comparator, plus IC2b and REF1, which provide an accurate reference voltage for the comparator.

As shown, the signal level is first attenuated using a 20kΩ and 10kΩ resistive divider and then coupled to pins 2 and 5 of IC3a and IC3b respectively via a 10µF capacitor.

REF1, an LM336-2.5, is used to provide a 2.5V reference, and this is applied to the pin 5 input of op amp IC2b. This stage operates as a non-inverting amplifier with a gain of 2, and provides a +5V reference at its pin 7 output.

This reference voltage is fed to a voltage divider network consisting of a 10kΩ resistor, trimpot VR2 and a second 10kΩ resistor to ground. As a result, two different reference voltages are applied to pins 3 and 6 of IC3a and IC3b, with VR2 used to set the voltage between these inputs.

These two reference voltages are labelled as TP2 and TP3 on Fig.3, and are equally spaced either side of 2.5V. Pin 3 of IC3a is set to the TP2 voltage, while pin 6 of IC3b is biased to the TP3 voltage. The pin 2 and pin 5 inputs of IC3a and IC3b are biased to the 2.5V reference set by REF1 via a 100kΩ resistor. As a result, the signal from IC2a swings above and below this 2.5V reference.

Note that IC3's outputs are open collector, so the outputs can be tied together. They are connected to the +5V rail via a 220kΩ resistor and so are normally held high.

Signal levels

Provided that the signal level at pins 2 and 5 does not exceed the reference thresholds (ie, doesn't go above or below these levels), the outputs of IC3a and IC3b will remain high due to the pull-up resistor. Conversely, if the signal exceeds one of these reference threshold voltages, the corresponding op amp will switch its output low.

Thus, if the voltage on pin 2 of IC3a goes above the reference voltage on pin 3, IC3a's output will switch low. Similarly, if the voltage on pin 5 of IC3b goes below the voltage on pin 6, output pin 7 of IC3b will switch low.

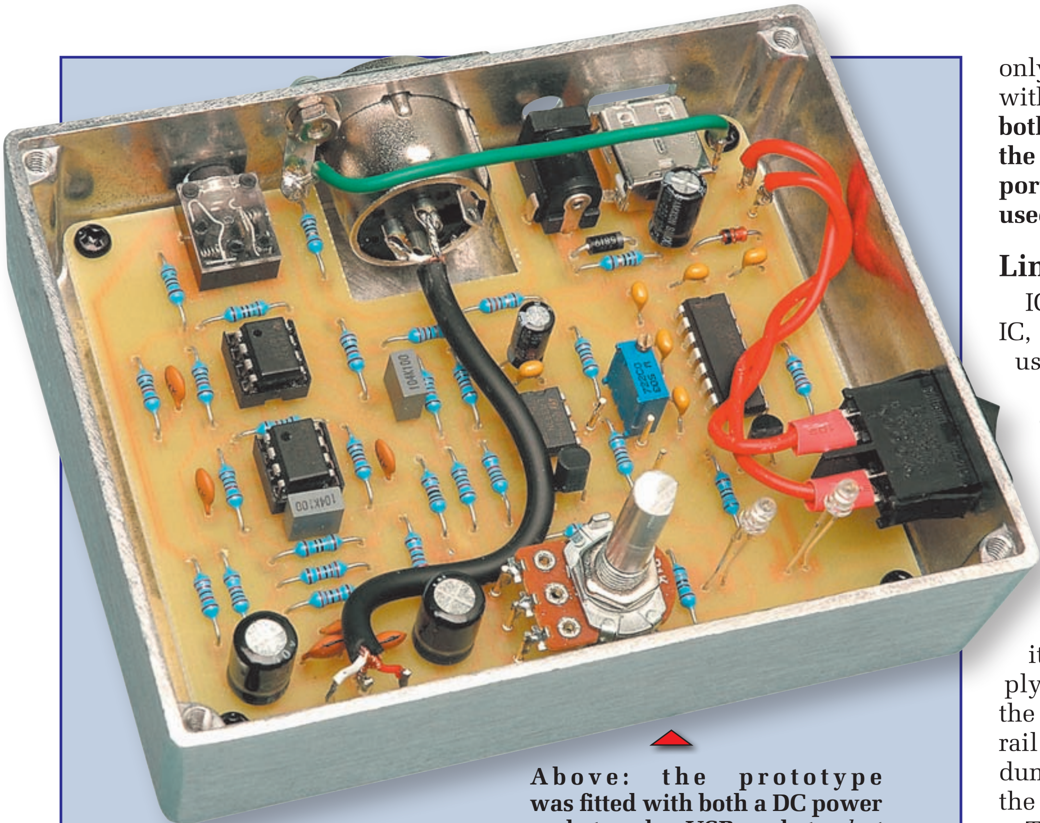
This output low from either comparator then turns on *PNP* transistor Q1 and lights the Peak indicator LED (LED2). The associated 1µF capacitor between the op amp outputs and the +5V rail ensures that the outputs remain low for 200ms after the comparator switches off, so that very fast overload transients aren't missed.

In practice, trimpot VR2 is set so that the TP2 and TP3 reference voltages are 442mV above and below the 2.5V reference respectively. This corresponds to a 1V RMS sinewave signal at IC2a's output.

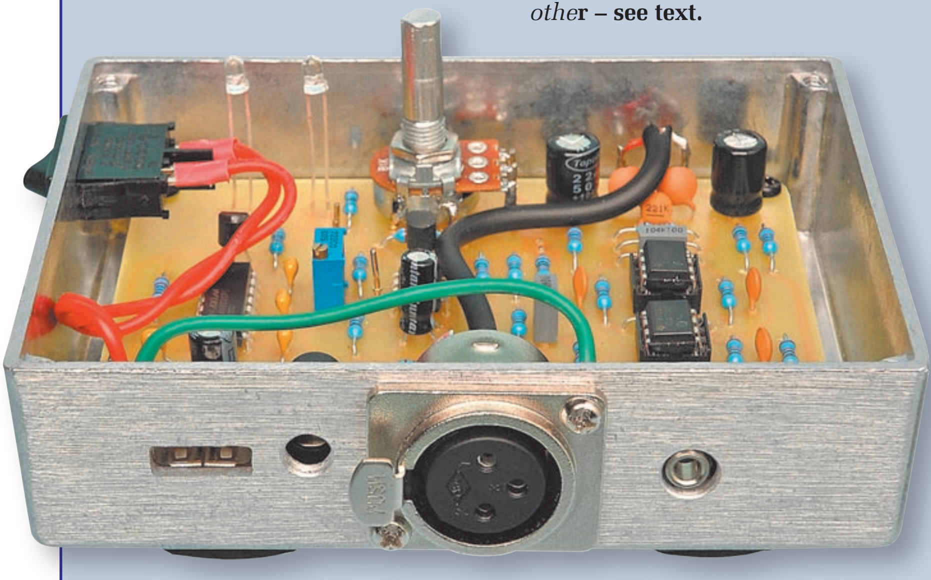
Note that for a 1V RMS sinewave, the peak voltage is 1.414V. This is divided by 3.2 using the resistive divider on IC2a's output and the 100kΩ resistor at pins 2 and 5 of IC3a and IC3b. As a result, the 1.414V peak is reduced to 441.8mV, which is why trimpot VR2 is adjusted for 442mV above and below 2.5V at 'test' points TP2 and TP3 to give peak indication when IC2a's output signal goes above the 1V RMS level.

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	220kΩ	red red yellow brown	red red black orange brown
❏	3	100kΩ	brown black yellow brown	brown black black orange brown
❏	2	22kΩ	red red orange brown	red red black red brown
❏	1	20kΩ	red black orange brown	red black black red brown
❏	11	10kΩ	brown black orange brown	brown black black red brown
❏	1	2.2kΩ	red red red brown	red red black brown brown
❏	2	680Ω	blue grey brown brown	blue grey black black brown
❏	1	180Ω	brown grey brown brown	brown grey black black brown
❏	2	150Ω	brown green brown brown	brown green black black brown
❏	1	68Ω	blue grey black brown	blue grey black gold brown
❏	1	39Ω	orange white black brown	orange white black gold brown
❏	2	33Ω	orange orange black brown	orange orange black gold brown
❏	1	10Ω	brown black black brown	brown black black gold brown



Above: the prototype was fitted with both a DC power socket and a USB socket – *but you should only fit one or the other* – **see text.**



The rear panel carries the XLR socket and has access holes for the USB connector (left), the adjacent DC power socket and the line output jack.

Power supply

As mentioned previously, the unit can either be powered from a USB port or via a DC plugpack. Diode D1 provides reverse polarity protection if a DC plugpack is used, while series resistor R1 depends on the plugpack voltage (see table on circuit).

In practice, any 300mA DC plugpack with an output voltage of 6V, 9V or 12V can be used.

A 100μF capacitor filters the incoming supply rail, while S1 is the power on/off switch. Zener diode ZD1 ensures that the resulting supply rail is limited to 5.6V to prevent damage to IC4, while R1 is necessary to prevent excessive current through ZD1.

Note that no reverse supply protection is provided for the USB supply since this uses a polarised connector that cannot be reversed. Note also that only one type of supply should be used with this preamplifier. **DO NOT install both a USB socket and a DC socket on the PC board, as damage to the USB port could occur if both supplies were used at the same time.**

Line driver

IC4 is a MAX232 RS232 line driver IC, but the line driver section is not used in this circuit. Instead, we are simply using it to generate the necessary *plus* and *minus* supply rails for the rest of the circuit.

Basically, the MAX232 includes two internal charge pumps that convert the +5V supply to nominal unloaded ±10V rails. The first converter switches capacitor C1 and dumps its charge into C3 to double the supply to derive the +10V rail. Similarly, the second converter inverts this +10V rail by switching C2 at a rapid rate and dumping the charge into C4, to provide the –10V rail.

This switching of C1 and C2 takes place at a nominal 400kHz rate.

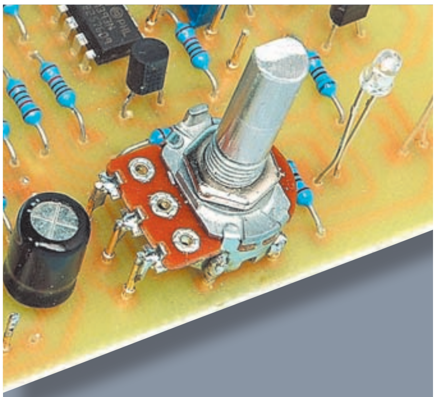
In practice, the resulting supply rails are loaded down to about +7V and –6V by op amps IC1 and IC2. Note, however, that the LM393 op amps (IC3a and IC3b) are powered directly from the +5V supply rail, to prevent excessive loading on IC4.

The positive and negative supply rails generated by IC4 appear at pins 2 and 6 respectively and are decoupled using 33Ω resistors. In addition, these rails are bypassed using a 100nF capacitor to minimise supply noise. The power LED (LED1) is driven from the +5V rail via a 680Ω resistor.

Finally, note that the signal earth for the preamplifier and the earth for the power supply are isolated via a 10Ω resistor. This reduces any current flow in the ground when the preamplifier is connected to a computer using both USB power and the stereo 3.5mm jack to feed in the signal. This is necessary because in this case there would be two earth paths between the unit and the computer – one via the USB connector and the other via the audio connection.

Construction

Construction is straightforward, with most of the parts mounted on a single-sided PC board, code 780, measuring 102mm × 83mm. This PC board is available from the *EPE PCB*



This close-up view shows how the Level Control potentiometer (VR1) is mounted on the PC board.

Service. The board is housed in a die-cast aluminium box measuring 119mm × 94mm × 34mm.

Begin construction by checking the PC board for any defects such as shorted tracks and breaks in the copper tracks. Check also that the hole sizes are correct by test fitting the major parts, ie, the 3.5mm stereo jack socket and either the DC socket or the USB socket. The holes for the four-corner mounting screws should be 3mm in diameter.

Finally, check that the PC board fits into the box and that the cutout has been made for the XLR socket.

Board assembly

Fig.4 shows the parts layout on the board. The resistors can be installed first. Table 1 shows the resistor colour codes, but a digital multimeter should be used to check each resistor before soldering it in place.

Follow these with the ICs, taking care to ensure that they are correctly oriented. Make sure also that the LM393 goes in the IC3 position. We used sockets for IC1 and IC2, but this is unnecessary and you can solder the ICs straight in if you wish.

Next on the list are PC stakes for all the following: test points TP1 to TP3, TP GND, the GND terminal, the switch terminals, the potentiometer mounts and its terminal connections, and the three input terminals (to terminate the stereo shielded cable from the XLR socket). Note that four PC stakes are used to support the metal body of VR1, which sits about 1mm above the PC board (see photos).

Transistor Q1 (BC327) and the LM336-2.5 voltage reference (REF1) can now be installed, followed by diode D1 and Zener diode ZD1. Take care to

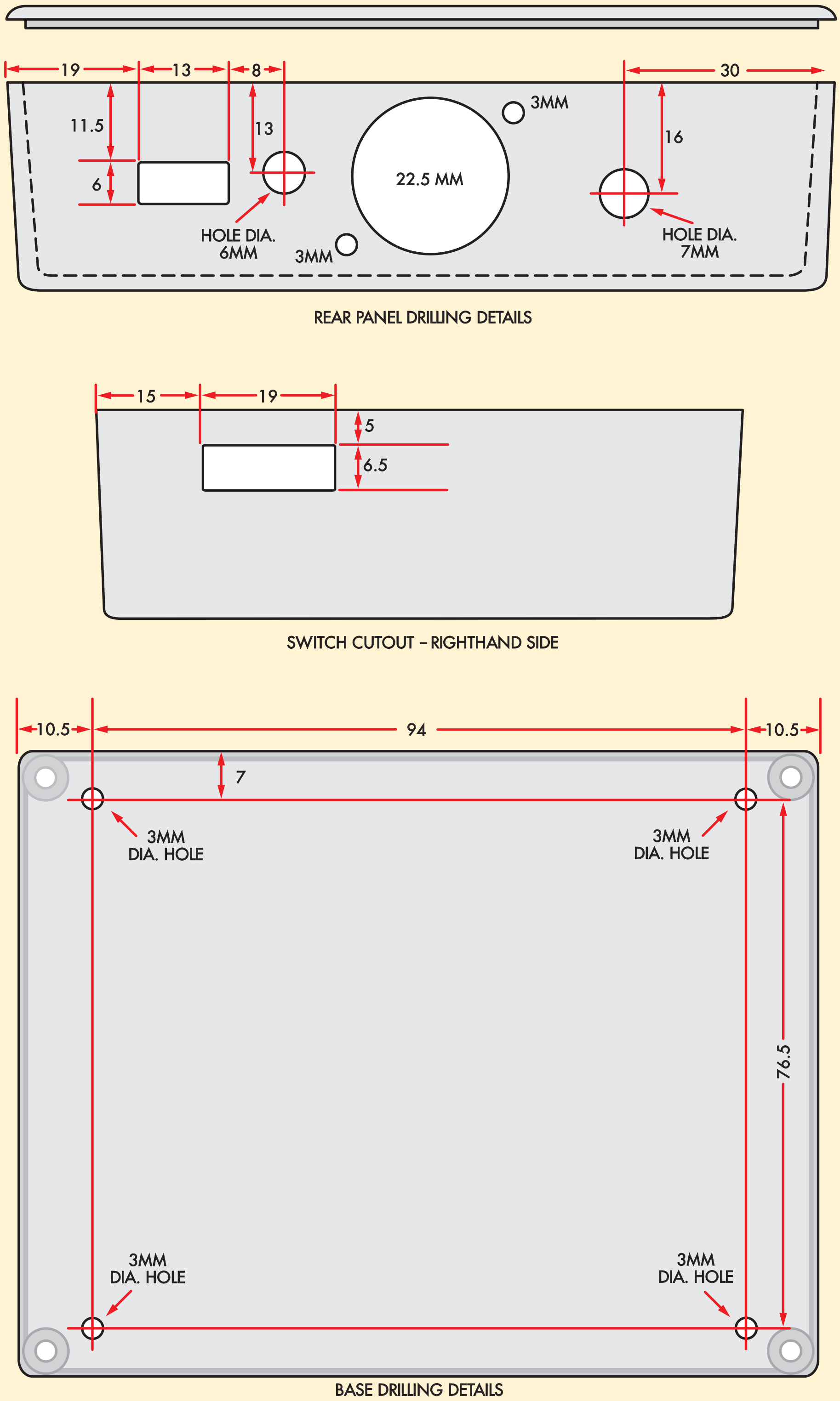


Fig.5: follow this diagram to mark out and drill the holes in the metal case. Alternatively, the diagram can be photocopied and used as a drilling template.

ensure that they are all oriented correctly and don't get Q1 and REF1 mixed up (they look alike). Note that D1 and ZD1 face in opposite directions.

The capacitors can go in next. Be sure to orient the electrolytic types as shown in Fig.4. That done, install the 10-turn trimpot VR2, then solder potentiometer VR1's metal body to its four PC stakes.

To do this, first bend the pot's three terminals down at right angles, then

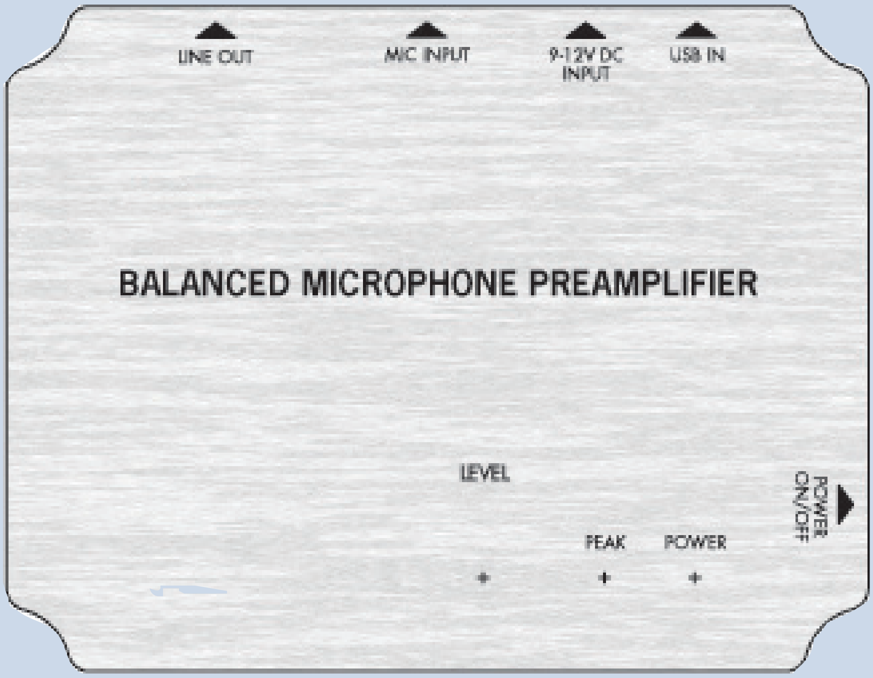


Fig.6: this full-size front panel artwork shows the hole locations for the Level control and the two LEDs. Drill the Level control hole to 7mm and the holes for the LEDs to 3mm

position the potentiometer vertically on the board and push its metal body down between the four PC stakes until it sits about 1mm proud of the board. Mark the solder points on the body, then remove the pot and scrape away the anodised coating at those points.

Next, cut the pot shaft off about 17mm from its threaded boss, then reposition the pot on the board and solder it's body to the four PC support stakes. The pot mounting can then be completed by soldering its three terminals to the adjacent PC stakes.

The two LEDs are mounted with the tops of their lenses exactly 25mm above the PC board. A 20mm-wide cardboard strip slipped between the leads of each LED makes a handy 'stand-off' tool when soldering them in position. Note that in each case, the anode (A) lead (the longer of the two) goes to the left.

Finally, you can complete the PC board assembly by installing the 3.5mm stereo jack socket and **either the DC power socket or the USB socket (but NOT both).** This depends, of course, on how you intend to power the unit. As previously stated, **you must not fit both because the computer could be damaged if both supplies were connected at the same time.**

Case preperation

If you buy a complete kit for this design, it will probably be supplied with all the case holes pre-drilled and with a screen printed front-panel label. If not, you will have to drill the holes yourself.

The full-size front panel layout is shown in Fig.6. This can be photocopied and used as a drilling template. You will need to drill 3mm holes for the Power and Peak indicator LEDs, plus a 7mm hole for the Level pot shaft. The latter is best made by drilling a pilot hole and then carefully enlarging it using a tapered reamer.

Next, you will have to drill holes in the rear panel for the 3.5mm jack socket, the XLR socket and either the DC input socket or the USB socket. Fig.5 shows the drilling details.

You will need to drill a 6mm hole for the DC input socket, while the stereo jack socket requires a 7mm hole. The square cutout for the USB socket can be made by first drilling a row of small holes and then carefully filing to the final shape.

The large hole for the XLR socket is a bit trickier to make. This hole is too big for most tapered reamers, so you will have to drill a series of holes around the inside circumference, then knock out the centre piece and carefully file it to shape. Its two mounting screw holes are each drilled to 3mm.

Next, a square cutout for the power switch must be made in the righthand side of the case – see Fig.5. Again, this is made by drilling a series of holes, then knocking out the centre piece and filing the hole to shape, until the switch clips into position.

Finally, four 3mm mounting holes for the PC board must be drilled in the base of the case. This is best done using Fig.5 as a template.

Once the box has been drilled, the next step is to **insulate the threaded ferrule of the 3.5mm jack socket with a short piece of heatshrink tubing, to prevent it making contact with the case.** This heatshrink tubing should be shrunk on using a hot-air gun, but be careful not to apply too much heat, otherwise you could damage the socket's plastic casing.

Internal wiring

The PC board can now be installed in the case. To do that, secure four 6.3mm tapped stand-offs to the base using M3 × 5mm screws, then place the board in position and secure it using another four M3 × 5mm screws and four M3 washers.

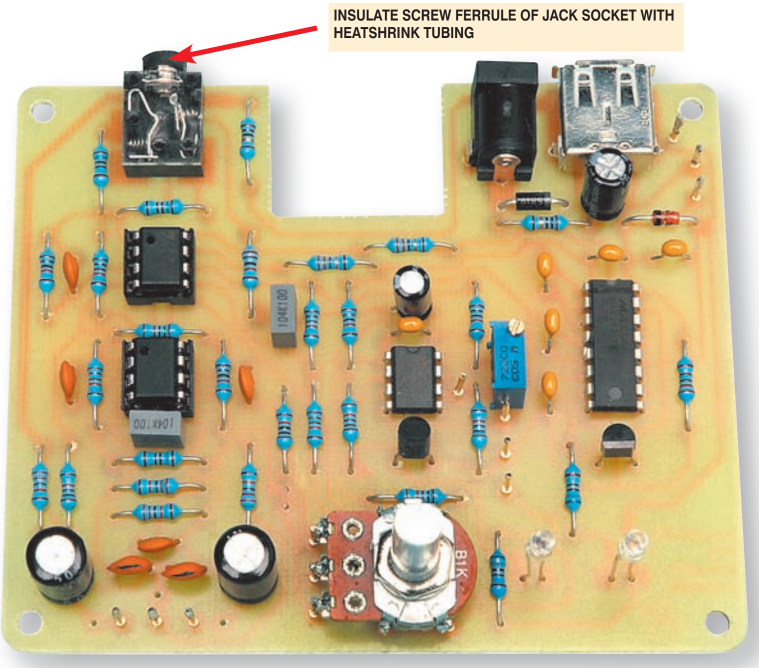
With the board in place, you can now fit the XLR socket and complete the wiring as shown in Fig.4. Note that 2-core shielded cable is used for the connections between the PC board and the XLR socket and that the pin 1 terminal on the XLR socket is the ground or shield pin. Note also that a solder lug is fitted under one of the XLR socket's mounting screws, to terminate the earth wire from the PC board.

Testing

To test the unit, first apply power and check that the power LED lights. Now measure the voltage between TPGND and pin 16 of IC4 – you should get a reading of 5V for a USB supply, or 5.6V if a plugpack supply is used. Check also that pin 4 of IC1 is about –6V, pin 8 of IC1 is at about +7V and that TP1 is at about 2.5V (with respect to ground).

If any of these voltages is incorrect, switch off immediately and check the supply wiring. Check also that IC4 has been installed correctly.

Assuming everything checks out so far, adjust trimpot VR2 so that the voltages at TP2 and TP3 are 442mV above and below 2.5V respectively (ie, TP2 should be +442mV with respect to



Be sure to insulate the threaded ferrule of the line output jack socket with heatshrink tubing. This ensures that it cannot make contact with the case and cause an earth loop which would lead to hum.

TP1, while TP3 should be –442mV with respect to TP1). This sets the peak level indication.

Note that because of resistor tolerances, you will not be able to adjust VR2 so that TP2 and TP3 are exactly the same value above and below TP1.

Note also that if you intend using this Balanced Preamplifier with a computer, then it's a good idea to set the peak indicator so that it agrees with the level indicator in your recording software.

Alternatively, if using this preamplifier with an MP3 player (ie, via the line input), adjust VR2 for the ±442mV levels at TP2 and TP3, then check that the sound is undistorted for all levels unless the peak level is exceeded.

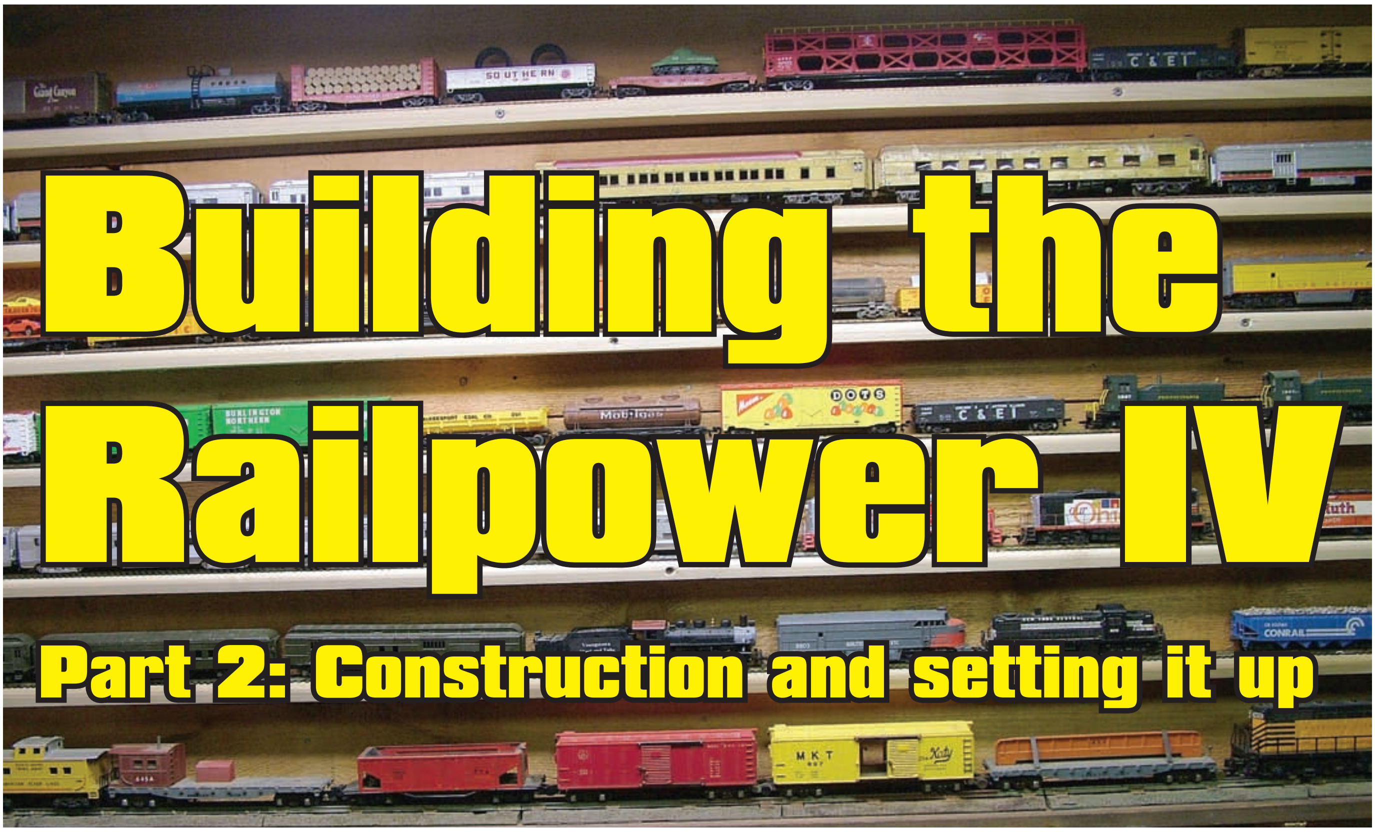
The assembly can now be completed by fitting four stick-on rubber feet to the underside of the box, then attaching the front-panel label, the lid and the control knob. Make sure that the two LEDs just protrude through their holes in the lid.

The front panel label (Fig.6) can be colour photocopied and trimmed to size. It can then be attached to the panel using either double-sided tape or a thin smear of silicone sealant.

Options

If you wish to have a through XLR plug (so that you can feed through the signal to another preamplifier or mixer), then you will have to use a diecast box measuring 119mm × 94mm × 57mm. Extra positions for PC stakes have been included on the PC board (at the front, left) for this wiring.

Finally, a switch can be added to close the connection between pins 2 and 3 of the XLR socket for microphone muting. ***EPE***



Building the Railpower IV

Part 2: Construction and setting it up

Last month, we presented the circuit, specifications and parts list for our new high-performance Railpower IV model train controller. Now it's time for the construction details – and we show you how to set it up for best performance.

by JOHN CLARKE

Considering that the new Railpower IV has such a lot of features and gives great performance, its construction is relatively simple. This is mainly as a result of using the PIC16F88 microcontroller.

This latest design uses two PC boards. The main board accommodates the power transformer and most of the circuitry, including the microcontroller, while the vertically-mounted display board is for the LCD panel and four pushbutton switches.

The main control board measures 217mm × 102mm and is coded 773, while the display board is coded 774 and measures 141mm × 71mm. Both boards are available from the *EPE PCB Service*.

These PC boards are housed in a plastic instrument case measuring 260mm × 190mm × 80mm. The rear panel is made from aluminium sheet. It provides heatsinking for the four Darlington power transistors (Q1 to Q4) used in the H-bridge motor drive circuit.

You can begin construction by checking each of the PC boards for defects, such as shorts or breaks in the copper tracks and to see that all holes have been drilled correctly to suit the various components. The holes for the mounting screws, the LCD mounts and for REG1 need to be 3mm in diameter. The four holes to mount the transformer are 4mm in diameter.

Note that there are different mounting positions for the dual in-line (DIL) or the single in-line (SIL) type LCD modules; the board has been designed to accommodate either.

Main board assembly

The component layout diagram for the main control PC board is shown in Fig.3.

Start construction by inserting the resistors in the main board, taking care to place each in its correct position. You can use the resistor colour code table (see last month's issue) as a guide to each value. You can also use a digital multimeter to check each resistor – this is a good idea because it is easy to misread colour codes.

Next, install the wire links and the PC stakes for the motor outputs and the 'track' LED. A 3-way pin header is used for connecting speed potentiometer, VR1.

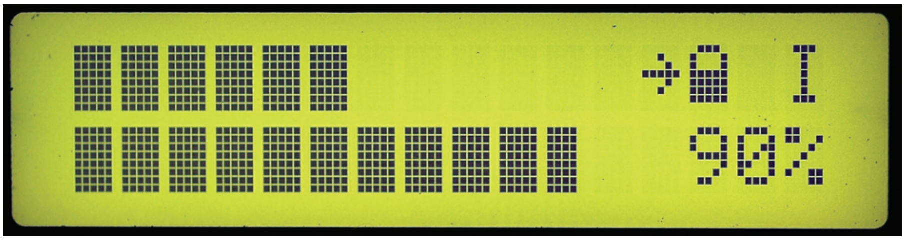
Install diodes D1 to D7, taking care with their orientation. Note that D1 to D4 are 1N5404 types, D5 and D6 are 1N4004 and D7 is a 1N4148. The socket for IC1 can now be mounted, taking care with its orientation (leave IC1 out of its socket for now). Then install IC2, again taking care with its orientation.

The capacitors can go in next. The five electrolytic types must be oriented

with the polarity as shown – see Fig.3. The crystal can then be mounted, as well as the piezo siren.

The voltage regulator (REG1) is attached to the PC board together with a U-shaped finned heatsink. Bend the regulator leads at right angles to fit into the holes provided. First secure it with an M3 × 10mm screw and nut and then solder the three leads. Next, install trimpot VR2 (10kΩ), the 2-way screw terminal block (CON3) and the 10-way IDC vertical header (CON2), mounted with the orientation slot as shown.

The transistors can now be mounted on the board. All the small-signal transistors (Q5 to Q10) are BC337 types. Just push them in and solder the leads. The TO-220 transistors are BD650 (Q1 and Q2), while Q3 and Q4 are BD649s. Mount them with their full lead length and with about 1mm of lead below the PC board for soldering.



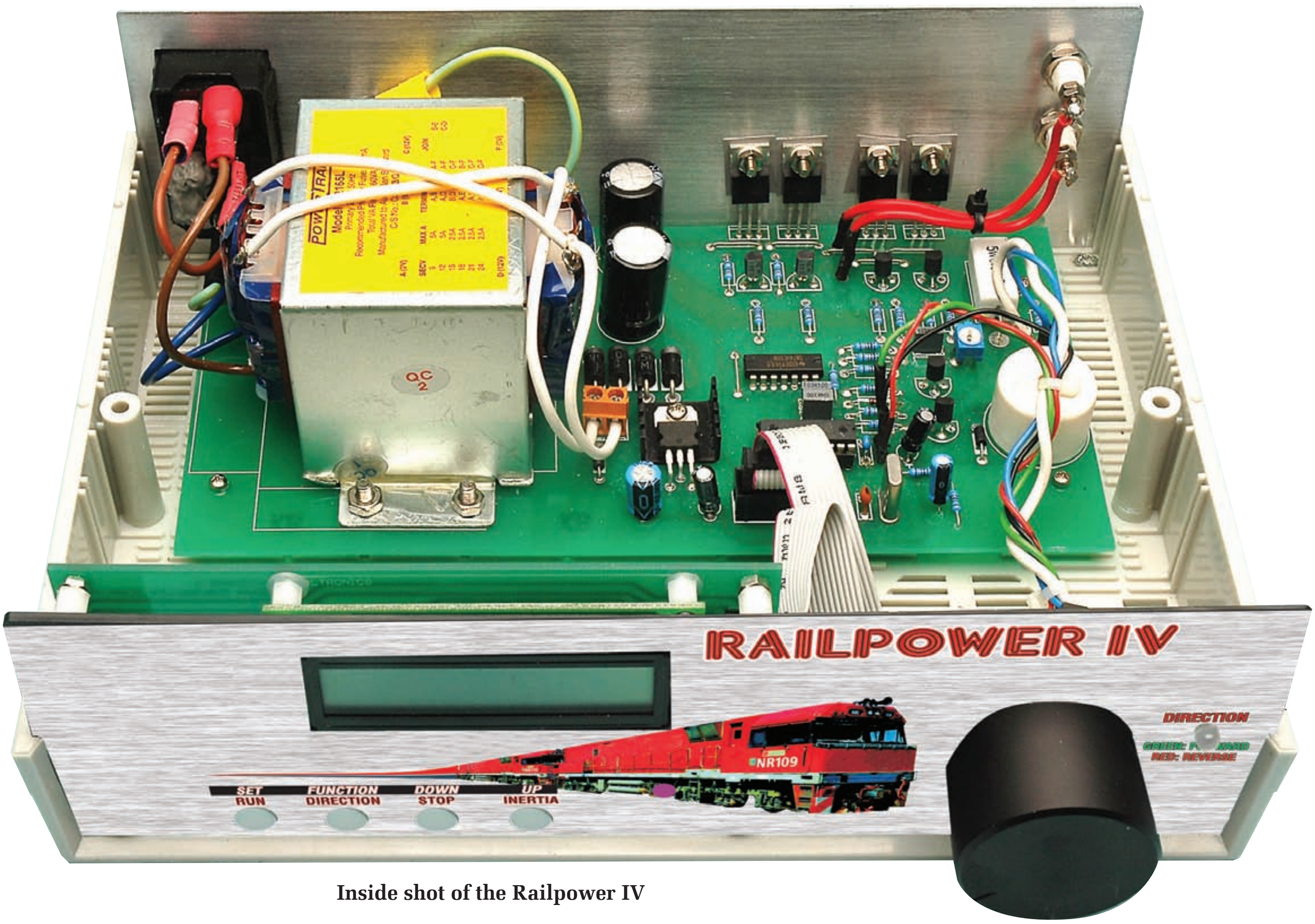
This is the two-line alphanumeric display (in this case the Jaycar model with backlight) which gives you all the information you need about your settings. Here it shows the train speed at about 56% of the maximum speed set (90%). Inertia is on (indicated by the 'I') and the lock is on (shown by the padlock being closed). As you enter other modes, the information on the display changes to reflect those modes.

Mains transfer

The power transformer (T1) is mounted on the PC board using four M4 screws and nuts. A 6.4mm spade terminal is attached to one corner, as shown, to earth the transformer body back to the rear panel – see Fig.6 and photos. You'll need to scrape off some of the varnish coating from around the hole. A star washer between the transformer mounting foot and the spade terminal then ensures a good contact.

To obtain the current rating required, two secondaries are wired in parallel, with *heavy-gauge* insulated hookup wire connecting the appropriate terminals, as shown in the photographs and in Fig.3.

Two wires, again *heavy duty* insulated hookup wire, are then run from the transformer secondary terminals to the adjacent 2-way screw terminal block (CON3). In fact, we used the same lengths of wire to connect the two terminals on the transformer and the terminal block.



Inside shot of the Railpower IV

Assembling the display board

Insert the five resistors and trimpot VR3 (10kΩ). The 100μF and 10μF 16V electrolytic capacitors must be laid on their sides before they are soldered into place.

The connections for the LCD modules are made with socket strip and with header terminal strips. You can use a 14-pin DIL (dual in-line) socket strip or a 14-pin SIL (single in-line) strip. This depends, of course, on which type of display module you will be using.

They can be made by cutting a 14-DIL IC socket to produce two 7-way strips. These can be placed side by side for the DIL or in-line for the SIL strip on the display PC board.

The header terminal strips are soldered to the LCD module. Install them with the longer pins sticking up through the LCD module PC board and then solder them in place on the topside of the module. The excess lead length on the topside is then cut short with side-cutters.

You can now plug the LCD into place on the display board. Secure the module using four tapped 6mm spacers plus nylon washers to increase height to about 7mm. These are secured in place with 8 M3 × 6mm screws.

The four pushbutton switches are mounted on the PC board, oriented with the flat side as shown in the component overlay diagram – see Fig.4. The infrared detector (IRD1) is mounted with its full lead length so it can be bent over at right angles. This means its lens lines up with the hole in the front panel. Finally, fit the 90-degree IDC connector (CON1).

You can make up the IDC lead with 10-way IDC cable, making sure that the red strip side is as shown on both the main board and display board sockets. The IDC cable can be compressed into its fittings by clamping up in a vice

Working on the case

Several holes need to be drilled in the front panel of the case for the pushbutton switches, the potentiometer and the IR detector (IRD1). A cut-out is also required for the LCD module – the size and location depend on whether the DIL type or the SIL LCD modules are used.

The larger holes can be initially drilled to 5mm to start with, and successively drilling larger holes. It can then be carefully reamed out to the required diameter. But why bother with all that? Why not use the correct size drill to make the holes in one go?

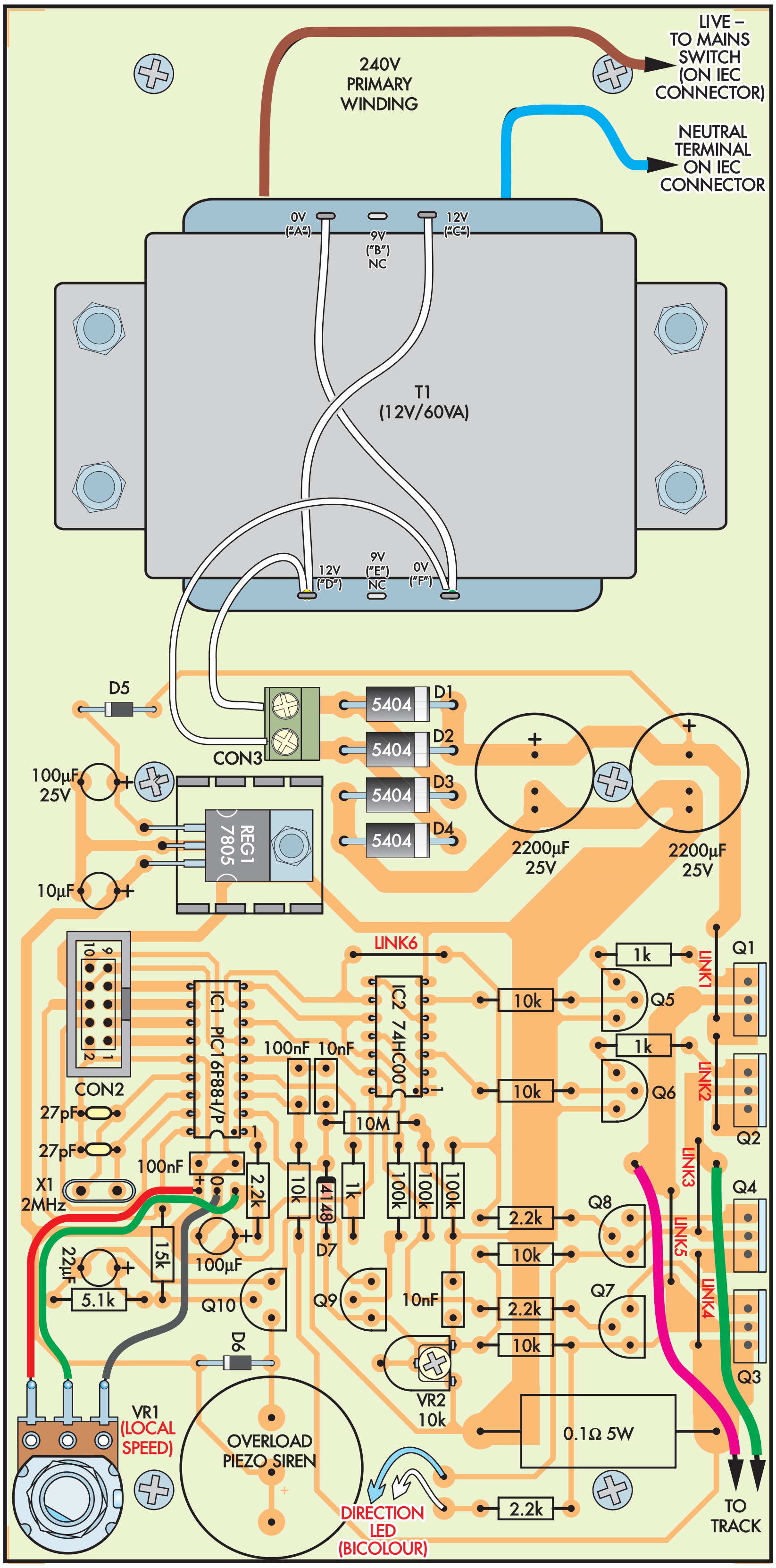
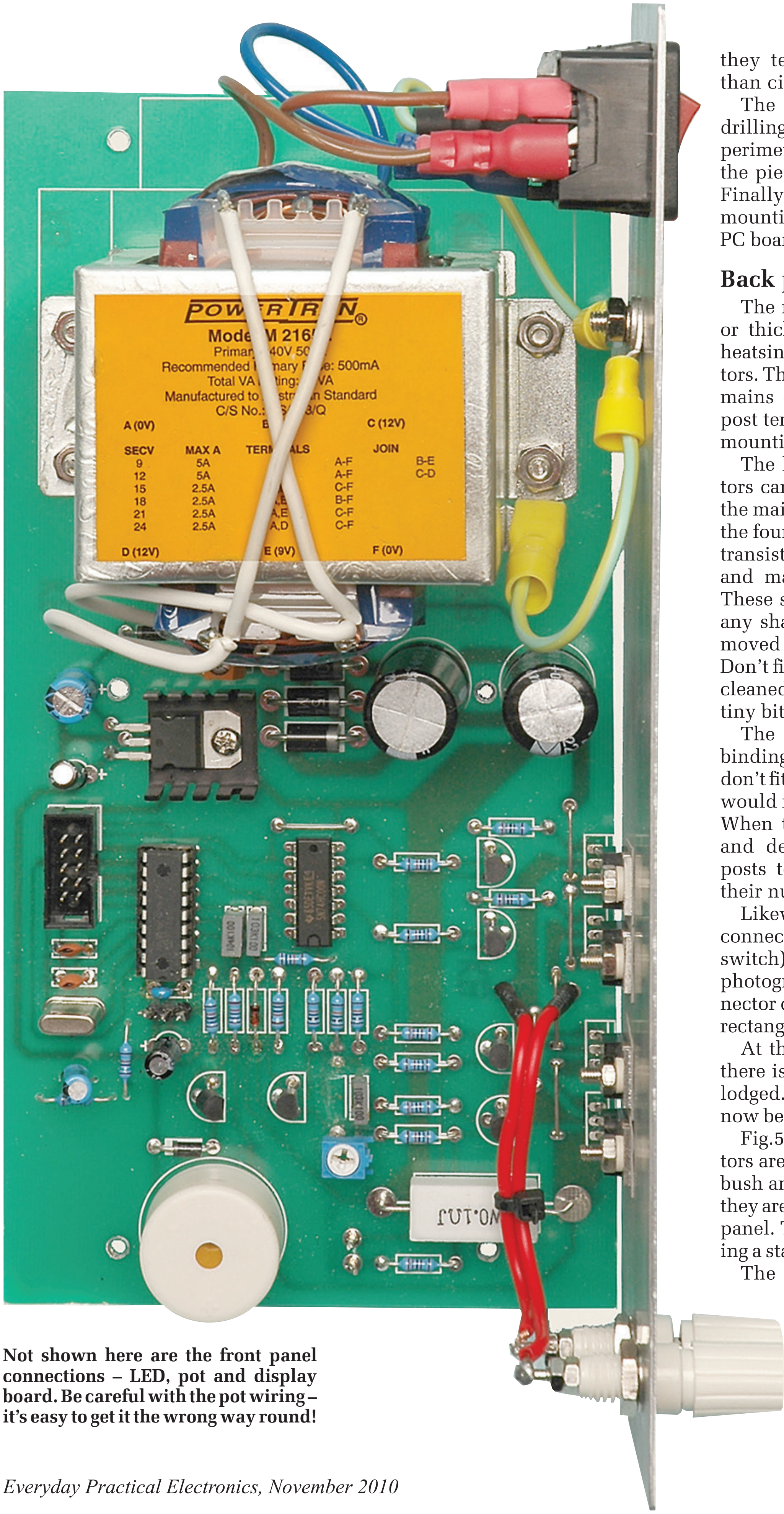


Fig.3: component overlay for the main PC board, with a similar-size photo at right for comparison. This has the back panel already fitted.

The reason is simply that it is almost impossible to drill large round holes in sheet material – usually



Not shown here are the front panel connections – LED, pot and display board. Be careful with the pot wiring – it's easy to get it the wrong way round!

they tend to be 'triangular' rather than circular.

The display cut-out is made by drilling a series of holes around the perimeter of the cut-out, knocking out the piece and then filing it to shape. Finally mark out and drill the four mounting positions for the display PC board.

Back panel

The rear panel is made from 1mm or thicker aluminium, to provide a heatsink for the four power transistors. The panel needs holes for the IEC mains connector, earth lug, binding post terminals and the four transistor mounting holes.

The hole positions for the transistors can be marked out by mounting the main PC board into the case using the four self-tapping screws. Push the transistors flat against the rear panel and mark out their hole positions. These should be drilled to 3mm and any sharp edges around the hole removed with a countersinking drill bit. Don't fit the transistors until you have cleaned up all the holes, just in case a tiny bit of swarf causes a short.

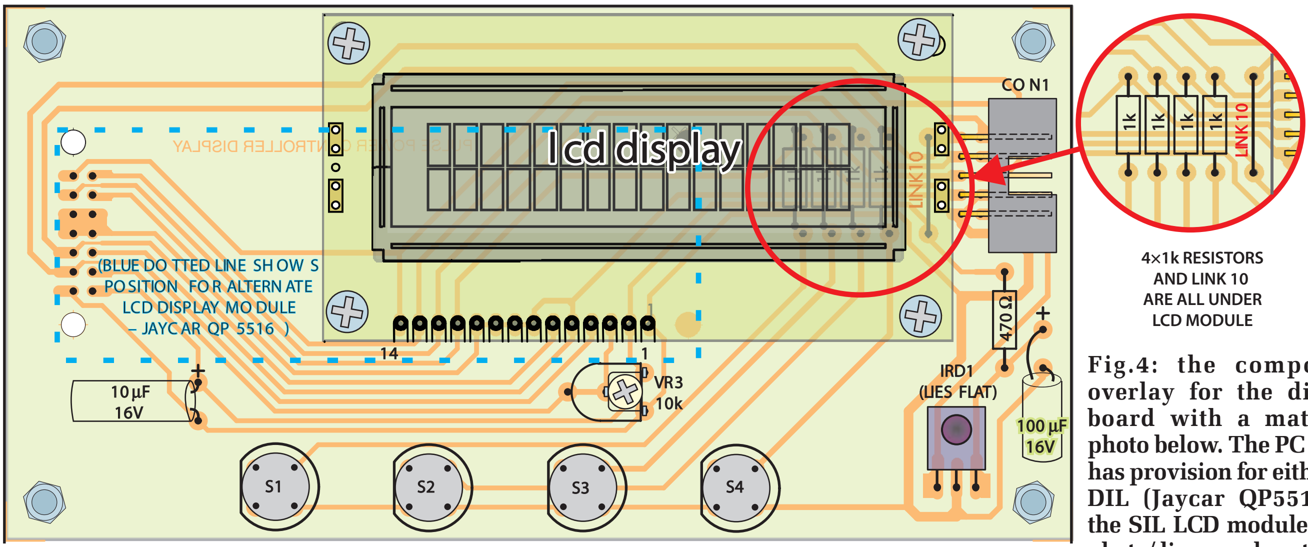
The position of the holes for the binding posts is not critical – just don't fit them too close together, which would make attaching wires difficult. When the holes are drilled, reamed and de-burred, attach the binding posts to the rear panel and tighten their nuts with a spanner.

Likewise, the position of the IEC connector (with its integral fuse and switch) is not too critical – use the photographs as a guide. The IEC connector clips into a 47 × 28mm vertical rectangular cutout.

At this size, it is a tight fit so that there is no likelihood of it being dislodged. The wiring inside the case can now be completed, as shown in Fig.6.

Fig.5 shows how the power transistors are mounted, using an insulating bush and washer as shown, to ensure they are insulated from the aluminium panel. The earth lugs are attached using a star washer between each eyelet.

The mains wiring is done with the brown and blue wires already connected to the specified transformer. Both are about 100mm longer than is required, so the off-cut from the Live (brown) wire is used to make up the



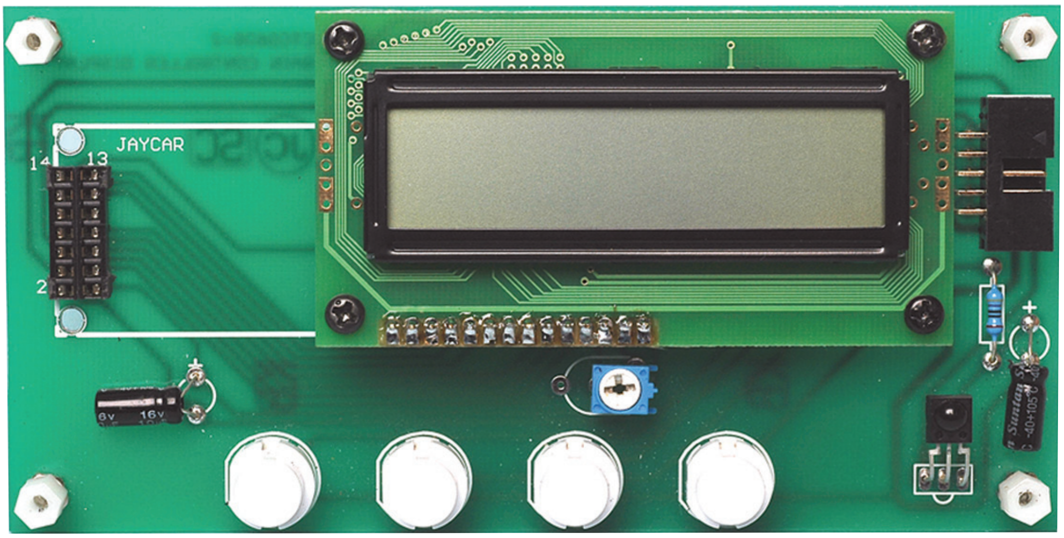


Fig.4: the component overlay for the display board with a matching photo below. The PC board has provision for either the DIL (Jaycar QP5516) or the SIL LCD modules, The photo/diagram show the SIL version, which connects to the PC board via a single row of 14 header sockets at the bottom of the display board. (The Jaycar version was shown in the photos last month. It connects via the dual row of sockets on the left side of the board). Note the inset above – four resistors and a link are actually under the SIL LCD module. Also note that for minimum height, the electrolytic capacitors and the infrared receiver (IRD1) are installed parallel with the PC board.

~50mm fuse-to-switch link on the back of the IEC connector.

Green/yellow-striped wire is used solely for the earth connections – one from the IEC socket earth pin to the rear panel, and one from the transformer to the same point on the rear panel. Together, these require only 150mm or so of wire. This coloured wire must not be used for any other wiring.

We used insulated 4.8mm crimped quick connectors for all wires going to the rear of the IEC connector, and insulated 6.4mm crimped quick connectors to the earth connections, as shown.

If for some reason you need to use any other wire for the mains wiring, ensure that is 250V AC-rated 7.5A wire, with brown used for Live and blue for Neutral.

For safety, all the mains wiring must be tied with cable ties so that they cannot come adrift. The exposed area at the rear of the IEC connector where the Live connects to the fuse should be covered with a liberal coating of neutral-cure silicone sealant.

The wiring to the transformer secondary and to the binding posts is made with heavy duty hookup wire. Note that the two 12V windings are connected in parallel. Connect the two 0V connections together and the two 12V connections together.

Before mounting and connecting the potentiometer, its shaft may need cutting to length to suit the knob to be used.

Power up

Note that the following tests and setup need the tracks connected and a 'loco' on them until indicated.

Check your wiring carefully, including the insulated covers over all the quick-connect terminals (these ensure that there are no dangerous voltages exposed with power connected, so that you can safely work on the project without it being sealed inside a case. There are no dangerous voltages on any tracks or pads on the PC board because the transformer is directly wired to the IEC connector).

Speaking of the IEC connector, make sure there is a 1A fuse inside its fuseholder. You open this by gently levering up the tab on the fuseholder

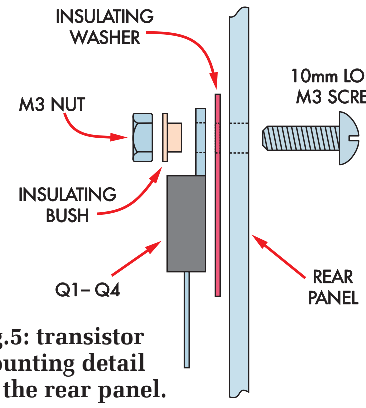


Fig.5: transistor mounting detail on the rear panel.

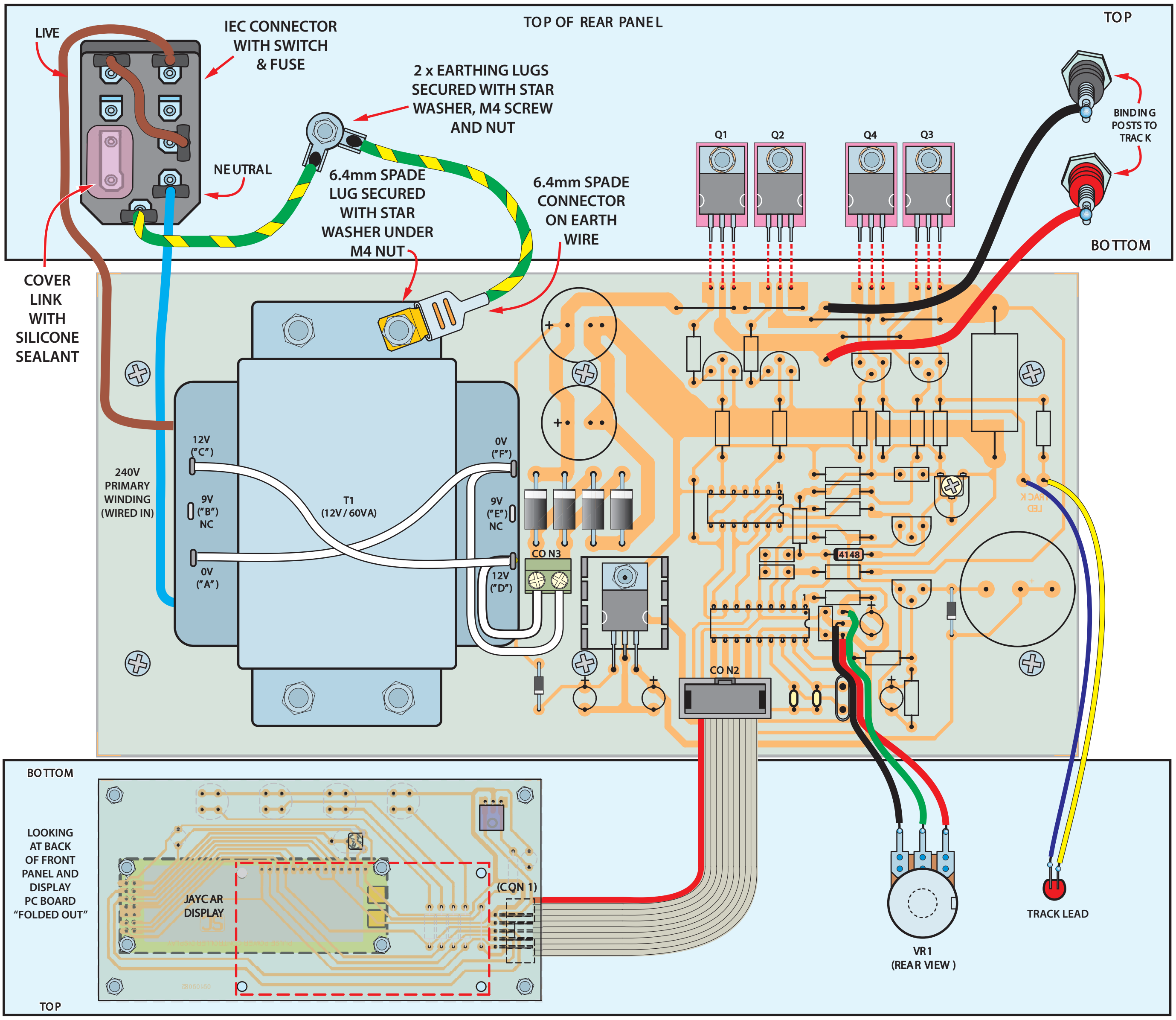


Fig.6: this 'opened out' view shows the wiring between the PC board and front/rear panels.

underside with a tiny flat screwdriver. And as mentioned earlier, IC1 should not yet be in its socket.

Apply power and check for 5V between pins 5 and 14 of IC1's socket. This may range between 4.9V and 5.1V. If the voltage is correct, switch off power and insert IC1 into its socket, taking care to install it the correct way around.

Reapply power and adjust trimpot VR3, so the LCD is easily viewed with good contrast. Note that you need to wait a few seconds after powering down before reapplying power. If you rapidly switch the power on and off, the LCD module may not reset correctly.

At this stage, the display should show a left arrow, an 'S' for stop and an 'I' for inertia on the top right of the display. The lower line of the display should show a bar graph and a percentage reading (0-100%) that varies depending on the setting of the Local Speed potentiometer (VR1).

The pushbutton switches below the display serve different functions depending on the Mode selected. At power up, the display is in RUN mode, where three of the switches control the Direction, Stop and Inertia.

If the Stop switch is pressed, then the 'S' should disappear and the top line will now begin to show a bargraph that increases slowly up to the speed setting value shown on the lower line. The Lockout (padlock) symbol will show as the speed increases beyond the first few bars on the top line. You should be able to switch the Inertia on and off with the Inertia switch and change the direction arrow when the speed is below the lockout speed. The direction will only change when the padlock lockout symbol is not showing.

If these tests are OK, then the display PC board can be attached to the front panel using 12mm tapped stand-offs and M3 screws. Countersunk screws are used on the panel for a flush finish.

Adjusting parameters

You are probably now ready to try out the controller on your model railway layout.

Connect the Railpower IV to the tracks by means of the terminals on the back panel and place a locomotive on them. Check that its speed can be controlled with the front panel knob.

At this stage, the maximum and minimum speed settings can be adjusted. To do this, press the Inertia

The Railpower IV rear panel, showing the positions of (from left) the track terminals, four transistor mounting bolts, earth bolt and the combination IEC mains input socket, fuse and power switch. Only the four transistor mounting bolt hole locations are critical – they need to line up with the transistors on the PC board. The IEC combo clips into a rectangular hole measuring 48 × 28mm – no screws are required.

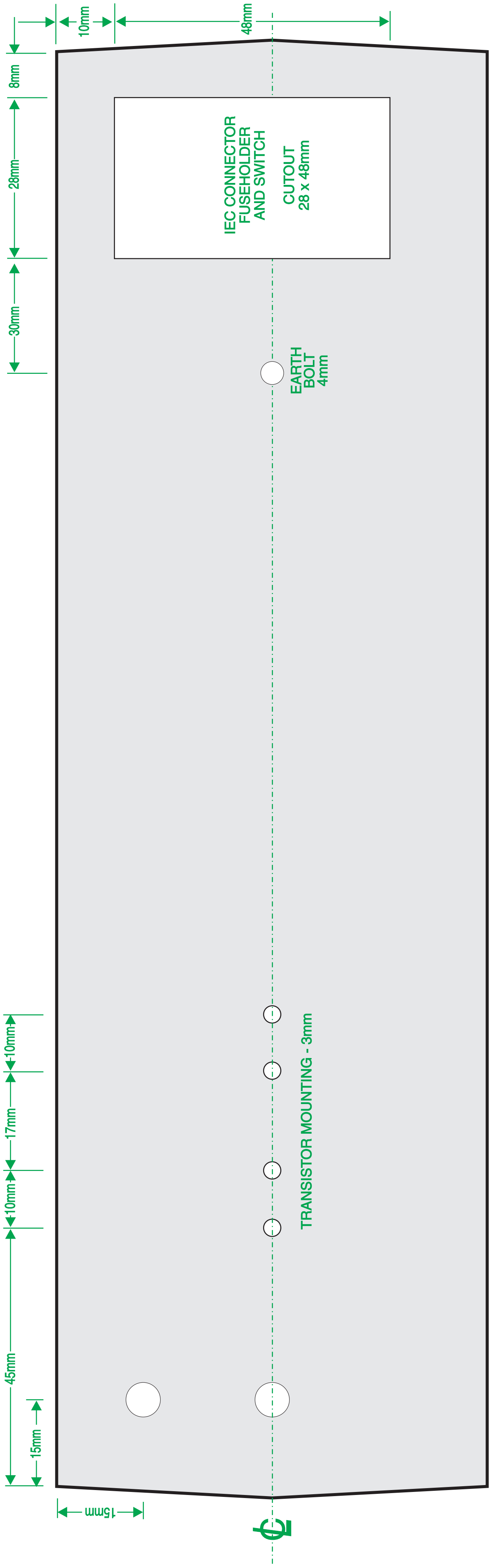
switch so that the 'I' is not displayed (inertia disabled). This will allow the locomotive to respond instantly to speed settings. Now press the RUN switch and the display will now show the SET mode in which the three right-most switches change their function to Function, Down and Up. Any changes made to the SET values are stored in memory unless they are changed again.

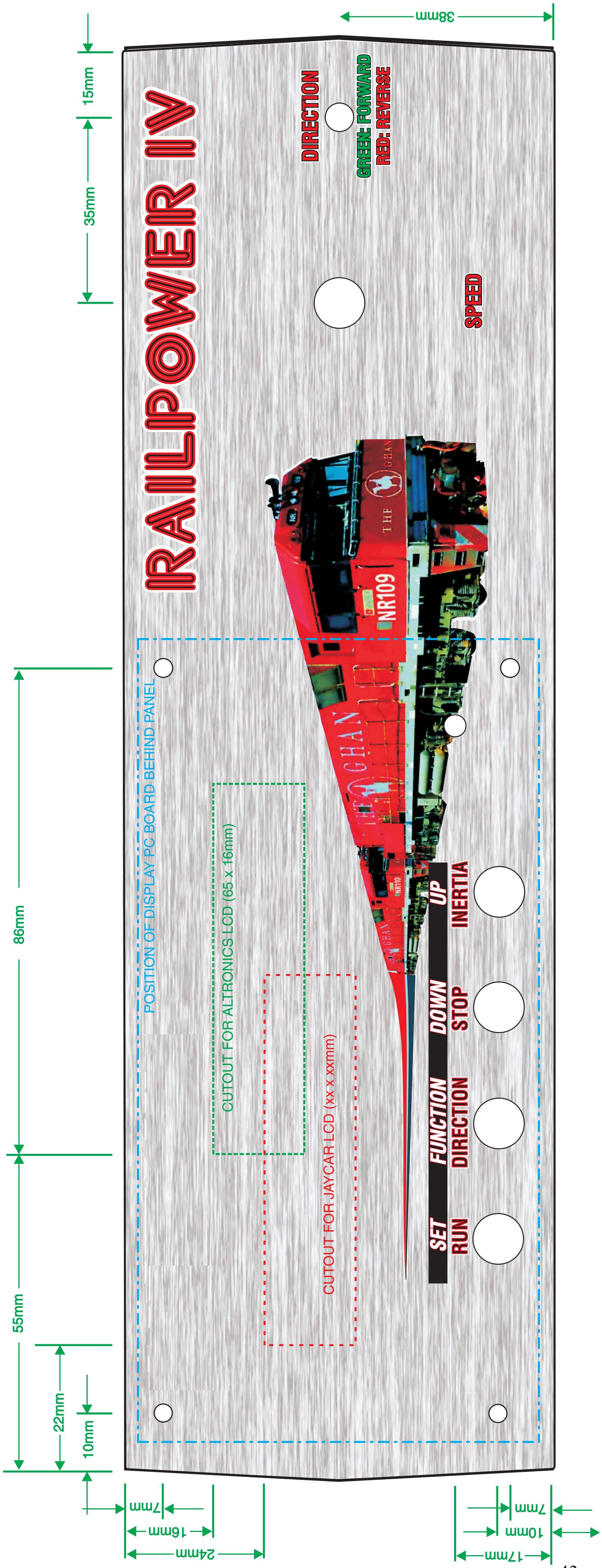
Each press of the Function switch selects the following:

MAXIMUM SPEED (self explanatory)
MINIMUM SPEED (self explanatory)
LOCKOUT SPEED (the maximum speed that reverse direction can invoke)
DEFAULT SPEED (the switch-on or default speed of the Railpower)
LOCAL/REMOTE (control is from front panel controls or infrared remote)
CODE TV (the code from your particular infrared remote – see the infrared remote instructions)
INERTIA (self explanatory)
STOP (self explanatory)
FEEDBACK (the degree to which back-EMF from the motor affects the Railpower)
SPEED RAMP (the rate at which the speed setting changes under remote control)
PULSE (the frequency of the interrupted DC going to the tracks)

Further details on what these mean and how to set them are shown in the programming panel on pages 44/45.

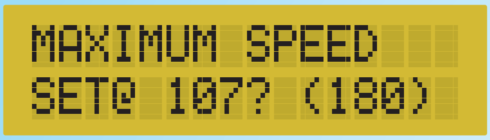
Opposite: Railpower IV front and rear panel drilling details, shown life size.


10mm
48mm
8mm
28mm
30mm
IEC CONNECTOR
FUSEHOLDER
AND SWITCH
CUTOUT
28 x 48mm
EARTH
BOLT
4mm
TRANSISTOR MOUNTING - 3mm
10mm
17mm
10mm
45mm
15mm
15mm


38mm
15mm
35mm
RAILPOWER IV
DIRECTION
GREEN: FORWARD
RED: REVERSE
SPEED
NR109
POSITION OF DISPLAY PC BOARD BEHIND PANEL
CUTOUT FOR ALTRONICS LCD (65 x 16mm)
CUTOUT FOR JAYCAR LCD (xx x xxmm)
UP
INERTIA
DOWN
STOP
FUNCTION
DIRECTION
SET
RUN
86mm
55mm
22mm
10mm
7mm
16mm
24mm
7mm
10mm
17mm

PROGRAMMING YOUR RAILPOWER IV

Maximum Speed



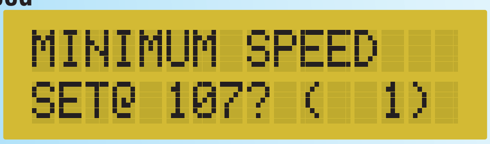
Press the Function switch until MAXIMUM SPEED is displayed on the top line of the display. The lower line shows SET@ 107? (180). The value 107 could be any number between 0 and 204 depending on the position of the Local Speed potentiometer. The number in brackets is the original default setting or your previous maximum speed setting.

Typically, you will want no more than 12V DC applied if you are running HO or OO-scale locomotives, and no more than 9V DC if you are running N gauge. If in doubt, check the manufacturer's recommendations. In fact, running an HO scale locomotive at its maximum of 12V will normally result in a scale speed of 180km/h, so for the sake of realism and safety, you might want to reduce it somewhat.

To set the maximum speed, wind up the Speed control until you get the desired DC voltage across the locomotive's motor, or you obtain the maximum speed you require. Depending on the different types of locomotive on your layout, the MAXIMUM SPEED setting may have to be a compromise.

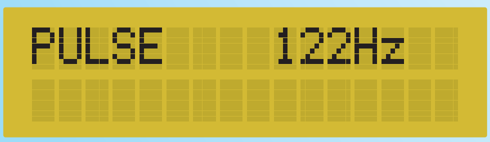
Once you have obtained the desired value, press the Up or Down switch and the display will momentarily show LOADED. Thus, the new maximum speed setting will be loaded and shown in brackets. The motor will now run up to this new maximum speed setting.

Minimum Speed



Now select MINIMUM SPEED and you go through the same process. In this case, the lower line shows SET@ 107? (1). Again, the 107 could be any number between 0 and 204 depending on the position of VR1, while the number in brackets is the actual minimum speed setting. Adjust the Speed control to a low setting that is just at the point where the motor stops (or is about to start) The SET@ reading will probably be around 1 to 5, or maybe higher with motors that require more voltage to start. Again, you can store this value by pressing the Up or Down switch and the word LOADED will appear briefly. The stored value will show in the bracketed section of the display.

Pulse



At this point you will probably become aware of the noise the locomotive makes at the low speed settings. If it is quite apparent, you may want to change the PULSE setting. Initially, it will be 122Hz and that is probably the optimum setting with most model locomotives, but give it a try at 488Hz or 1953Hz.

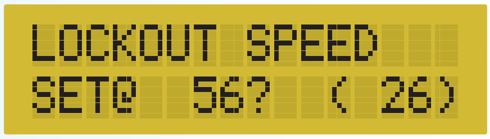
Once you have decided on the PULSE frequency setting, you may need to go back and reset the MINIMUM SPEED. You cannot have the minimum speed setting the same as or larger than the maximum speed setting. If you make a mistake here, you need to redo the adjustments. Generally speaking, you would need to initially select 204 for the maximum and 0 for the minimum values first before readjusting the minimum and maximum values again for your requirements.

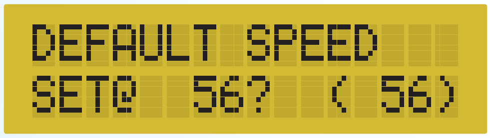
Note that while the displayed numbers range from 0 through to 204 in increments of 1, the actual control is over 816 values. So, depending on the resolution of the Speed control potentiometer, it is possible to obtain up to four speed settings between each value increment on the display. This extra resolution can be useful for the minimum speed setting. The stored values include this extra resolution.

Note also that if you are using a standard 16mm potentiometer for the Speed control, this fine resolution probably will not be possible.

Lockout and Default

LOCKOUT and DEFAULT speeds can now be adjusted.



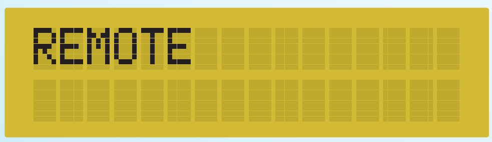


Lockout sets the speed above which forward and reverse changes are prevented, ie, 'locked out'. We suggest that you set it to a very low speed, similar to that used in shunting.

The Default setting is the speed that is applied each time you turn on the Railpower when the remote control is used. It does not apply when you are using the front panel Speed control (local).

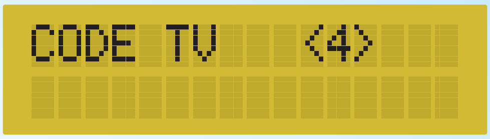
Initial default settings for Maximum, Minimum, Lockout and Default are 180, 1, 8 and 64, respectively.

Local/Remote



The Local/Remote setting selects whether speed is controlled via the front panel Speed control or the infrared remote control. You can toggle between either setting using the Up or Down switches.

Code

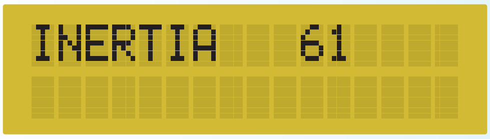


Next, you need to select the CODE for the infrared remote control. You can select between TV, SAT1 or SAT2 using the Down switch. Normally, TV would be selected (the default setting). SAT1 or SAT2 are used when you have more than one Railpower controller used on the same layout vicinity.

Note that there is a number in brackets (0 to 9) following the code selection. This sets the rate at which the Railpower decodes the infrared data, because some remote units are slow or fast compared with the correct data transmission rate of the RC5 code. The number can be changed using the Up switch. In practice, you select the number that works best with your remote unit.

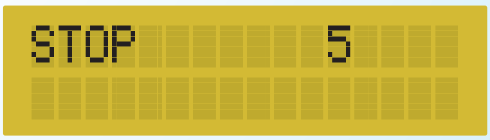
Note that if you press the RUN/SET switch, the display is returned to the RUN mode showing the speed settings. You can then test the remote unit for reliability. You can quickly toggle between the settings mode and the CODE selection using the Mode switch.

Inertia



INERTIA is the next selection. This selects the rate at which a locomotive changes its speed (accelerate or decelerate). The number is adjustable from 0 to 100, using the Up and Down switches. You will want to try several different values, depending on the size of your layout and the locomotives and length of the trains to be run. If you are using Inertia value of 60 or more, the locomotive will take several minutes to reach its set speed from a complete stop, or to go from the set speed to stop.

Stop



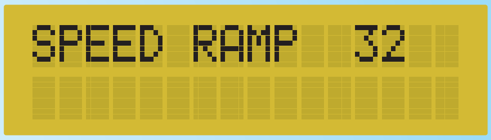
The Stop value is selected next, and is the rate at which the locomotive comes to a halt when the Stop button is pressed. It also can be adjusted from between 0 and 100, but typically you will not want to use very high values otherwise it is too difficult to judge just when and where the locomotive will come to a halt.

Feedback

The Feedback value can be set between 0 and 100 and corresponds to the degree that the motor back-EMF affects speed regulation. A low value will mean that the locomotive will tend to slow down more when pulling a train up an incline. Hence, the setting you use will be a compromise between ease of running trains around the layout versus reality, ie, a heavy train should slow down when going up a hill unless the throttle is advanced.

Trimpot VR2 also needs to be adjusted to provide optimum control. Generally, VR2 is set so the motor speed does not change much (when set to a slow speed) between feedback values from 0 to around 40 or 50. If in doubt, just set VR2 is to mid-point.

Speed Ramp



The Speed Ramp value, adjustable from 0 to 255, selects the rate at which the Speed Setting will change when under infrared remote control. If 0 is selected, the speed setting will change slowly under remote control.

In practice, a setting between 10 and 20 is fine. Any faster than that and you will find it tricky to make small changes in speed.

Universal remote controls

Further testing requires a universal or 'pre-programmed' remote control. In this case, one with very few controls is the way to go. If you are going to build only one Railpower for your layout we suggest the AR-1703 from Jaycar. It is small and only has the control buttons you need. However, it does have one drawback, and that is that it can only be used for the TV code.

If you intend to have more than one Railpower on your layout, you will need a remote control with the SAT1 and SAT2 codes available.

Programming the remote

The best approach to programming the remote control is to initially program it for a Philips brand TV (just follow the instructions supplied with the unit). In most cases, programming involves simultaneously pressing the 'Set' button and the button for the item that is to be operated. In other words, press the 'Set' and 'TV' buttons together and enter a number for a Philips TV set.

For the Jaycar AR-1703 remote use 11414. If you are using a different remote control, just select a number for a Philips TV set. If you later find that this doesn't work, try another number for a Philips TV.

Having programmed the remote, check that the Speed can be raised or lowered when the Volume Up and Down buttons are pressed. Check that the directions can be changed with the channel Up and Down buttons. Also check that the Mute button stops the loco and the Operate button switches Inertia on and off.

Recycle It!

BY JULIAN EDGAR www.julianedgar.com

Top Ten Parts

Top of the hit list

EACH month I discuss what good parts you can get out of most discarded consumer goods. One month I might tackle a VCR (one of my absolute favourites to salvage parts from!); another month I might show you what you can get out of a breadmaker or hair trimmer.

But what about looking at it from the other end of things – examining the components you should always collect, irrespective of the item you're salvaging the parts from? In a way it's even more useful to highlight those parts you should always grab, because then it doesn't matter what you're disassembling. With this in mind, I would like to offer my 'top ten' selection of parts/items that take priority for the 'salvage it' treatment

1. Knobs

Whenever you see a piece of equipment with quality knobs on it, grab them! It takes literally seconds to pull knobs off and it makes such a difference when you're building a project if you can just go to your storage drawers and immediately lay your hands on a knob that's just perfect for the application.

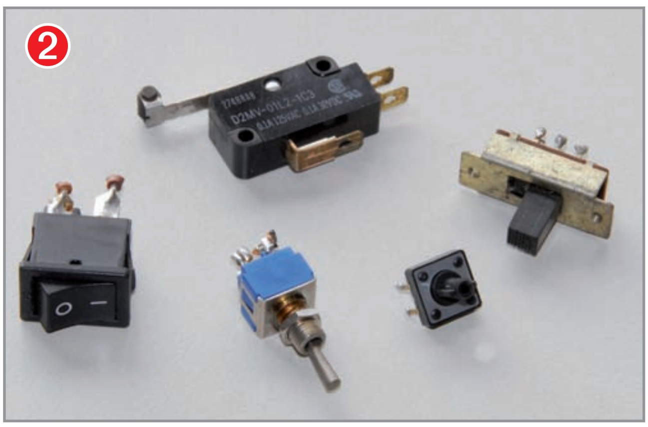
It's also interesting sorting through different knobs and feeling the way in which they work – some knobs (eg an amplifier volume control) needs to be large and smoothly contoured; others (like the adjustment knob on an electronic thermostat) need to be small and much better shaped to suit fingers and fine adjustment.

2. Switches

A switch is one type of electronic component that doesn't go out of date. Over the years, I've collected switches from VCRs (miniature pushbuttons off their PCBs), from photocopiers (the switch that deactivates the power when the lid is raised is usually a very heavy-duty pushbutton), and from electric typewriters (typically the main on/off switch is a quality push-fit rocker design).

From amplifiers, I go for the input selection multi-pole rotary switch; and from VCRs, the contactless Hall effect switches often used on the video drum chassis. From older washing machines, I keep the very sensitive pressure switch and from miscellaneous heavy-duty equipment, high current solid-state switches. All are useful – and even better, easy to use.

Whenever you see any discarded pieces of equipment with quality knobs on it, grab them!



A switch comes in all disguises and is one electronic component that doesn't go out of date

3. Cable clamps, mounts and holders

Whenever you run wires or cables inside a piece of equipment, there's a need to hold them in place. (Well I guess there often isn't actually 'a need', but for good appearance, servicing and safety, you should always corral wires.)

Inside commercial equipment you'll find the full gamut of cable and wire holders – bendy insulated metal strips, steel clamps, plastic clamps, clamps that pop into chassis holes, and clamps that hold mains-power cables. It's always worth collecting these clamps, mounts and holders.

4. Fuses

Fuses are another example of a component that doesn't date – a 50-year old glass fuse and fuseholder are just as useful today as back then. As a matter of course, I collect fuses from all sorts of equipment – and if the fuseholder is either an inline or easily removed chassis mount design, I collect those too.

You can also obtain very useful fusible links from car fuse and relay boxes, and much industrial equipment contains resettable circuit breakers. I also collect the two different sizes of blade fuse used in vehicles.

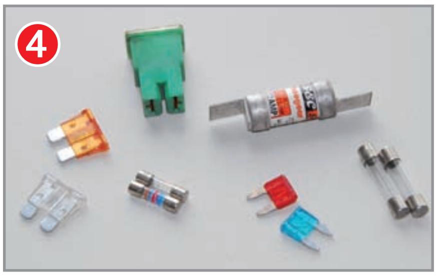
With only half an eye being kept out, it's not at all hard to collect enough fuses that you'll never need to buy one again – or spend the time travelling to the shop to buy that required obscure value.

5. Relays

Relays are extraordinarily useful – rugged (basically impossible to blow up unless you do something really stupid!), universal within voltage and current restraints, and easy to wire into place. An enormous range of equipment and appliances has relays inside – you can easily collect one from even moderately complex bits of gear you salvage.

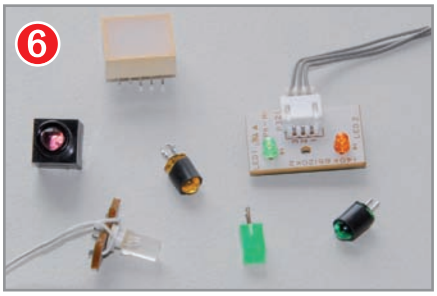
Relays (and many other parts) can be removed from PC boards quickly and effortlessly by using a heat gun aimed at the solder side of the board and plucking out the relays with long-nosed pliers. I remember picking up an ABS (anti-lock braking) controller from a car and realising with joy that it contained no less than six small, high current 12V relays!

Whenever you run wires or cables around the housing of your project, there's always a need to hold them in place. Well, there's a grand selection of cable and wire holders inside commercial equipment just waiting to be 'recycled'



Fuses are another example of a component that doesn't date. It's not too hard to collect enough fuses from 'dumped' equipment to never have to buy another one again

Relays are extraordinarily useful, easy to wire into place and often found in even moderately complex pieces of gear



The idea of salvaging LEDs can seem silly – why bother when they are so cheap? First, it's easy to salvage ones that you cannot purchase easily from shops. Second, using a heat-gun and long-nosed pliers, it takes almost no time to salvage dozens of LEDs

6. LEDs

The idea of salvaging LEDs from equipment can seem silly – why bother when LEDs are so cheap new? There are two answers to that question.

First, it's easy to salvage LEDs that you cannot readily buy in shops – surface mount, those with odd lens shapes (eg long rectangular), and LEDs with unusual colours. Second, using the heat-gun-and-pliers approach mentioned earlier, it takes almost no time to salvage dozens of LEDs.

Often in projects I'll use shop-bought LEDs, but nearly as frequently, I'll want something out of the ordinary and reach for my little drawers of salvaged LEDs.

7. Plugs and Sockets

If you're trying to find the right plug for a socket (eg a DC socket that requires the correct mains adaptor) a visit to an electronic supplier is most often required. But if, on the other hand, you're building a piece of equipment and need a similar function low voltage DC plug-and-socket combination, it's often much easier and cheaper to use some that you've salvaged.

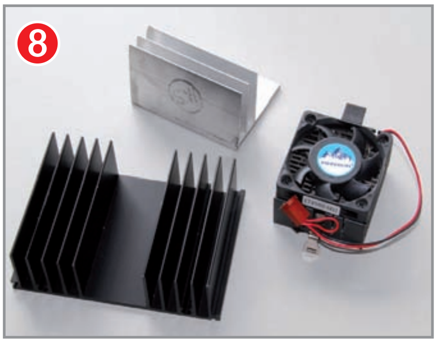
For example, I often use RCA-style plugs as low voltage DC power connections – they're polarised, non-shorting, handle reasonable current – and you can salvage RCA phono sockets from any audio or video consumer item that's been thrown away. And the plugs? They're almost as often discarded on audio interlink cables!

The range and combinations of plugs and sockets seems to be endless, and you will certainly need to build up a large stock of these if you're into project building

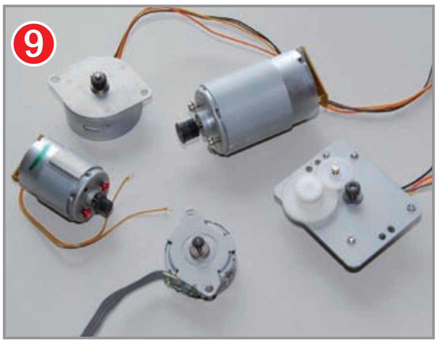
8. Heatsinks

Heatsinks are available in discarded goods in a huge range of sizes – from small 'tab' style ones in power supplies to large heatsinks in audio amplifiers, and every size in between.

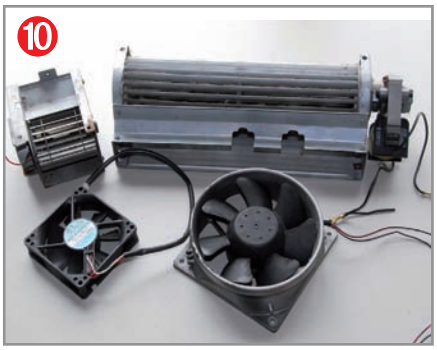
When building projects it pays to have a large variety of heatsinks on hand. That's because there is often not only a requirement for heat handling, but also physical requirements as to size and shape.



Heatsinks are available in discarded goods in a huge range of sizes – from small 'tab' style ones in power supplies to large heatsinks in audio amplifiers



Many items people throw away contain electric motors – from small low-voltage and stepper motor types to larger mains-powered washing machine motors



Cooling fans inside redundant equipment come in all shapes and sizes. Most fans are typically either mains-powered or run off 12V or 24V DC

In Store

So you're a dyed-in-the-wool salvager, grabbing discarded items and pulling them apart with dedication. Now, what do you do with the accumulated bits?

It's a vital question, because if the components are not sorted and stored in a logical way, you will never use them. Don't believe me? Well, imagine what it's like if you just put all the salvaged parts in a big box. You're working on a project and you need a knob. You look at the big box – which you remember contains some knobs – and then say: 'Nah, it's easier if I just go to a shop and buy a knob – much simpler than trawling through that darn box of junk!'

Contrast that with an arrangement like the one outlined here. You want a big knob? Literally two seconds later you can be examining four different designs of big knobs.

You want a switch? Will that be a rocker, toggle, slide or miniature pushbutton, sir? Again, with organisation, it's a two-second job to home-in on the right drawer.

Sorting your parts has another advantage: it shows you what you

are missing, and the parts you need to look-out for.

In short, invest in sets of little drawers, compartmentalised plastic boxes that used to contain fishing gear – anything like that. And these drawers? Unbelievably, they were on their way to the local rubbish tip and needed only a clean and new labels before being put to good use.

For example, space might be tight in one direction, or the flat mounting surface on which the components are to be mounted might need to be a certain shape. I collect all heatsinks that I come across – and they're among my 'most-utilised' salvaged parts.

9. Small Motors

Many items that people throw away contain electric motors. Breadmakers use mains-powered universal carbon brush-type electric motors; electric typewriters, printers and fax machines use stepper motors; and VCRs contain small low-voltage brushed motors. And, of course, washing machines and other larger goods contain mains-powered induction motors.

I tend to collect just the following types of motors: small low-voltage brushed (good for making fans and kids' toys), and large and small stepper motors (good for robot, model railways and hand-cranked generator projects). Motors (of any sort) that can be removed complete with reduction gear-trains are always useful.

Incidentally, unwanted stepper motors (especially in larger size and in matched pairs) can normally be sold for decent money on eBay.

10. Fans

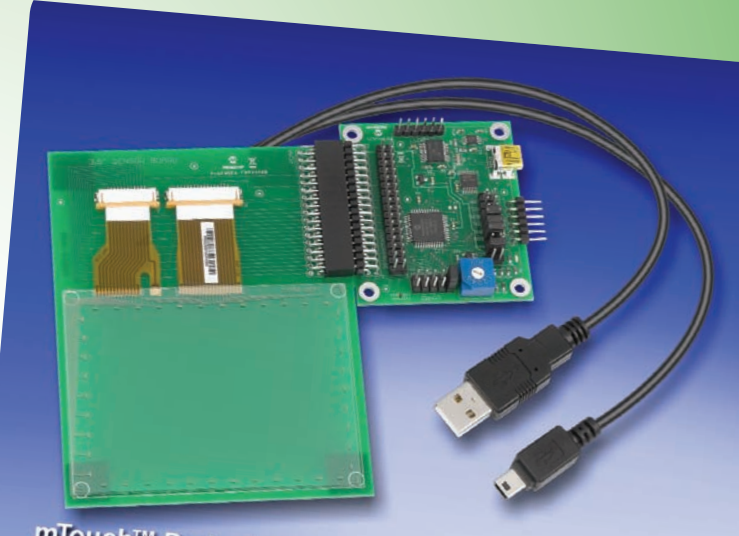
Cooling fans inside discarded equipment come in all shapes and sizes. PC-style fans can be found in PCs(!) and photocopiers. Fans with removable blades can be salvaged from microwave ovens (*but only open a microwave if you know exactly what you are doing – they can be very dangerous*), while 'squirrel-cage' fans are used in much industrial equipment as well as some types of domestic heaters.

Fans are typically either mains-powered or 12V or 24V DC. (Note the 24V fans will still work on 12V, just rotating more slowly, and quieter.) I use a squirrel cage fan in my home-built audio amplifier (much quieter than a typical PC fan), and a PC fan to cool a battery charger made from salvaged parts. ***EPE***

Win a Microchip mTouch Projected Capacitive Development Kit!

EVERYDAY PRACTICAL ELECTRONICS is offering its readers the chance to win an mTouch Projected Capacitive Development Kit. Microchip's mTouch™ Projected Capacitive Development Kit (P/N DM160211) provides a fully functioning projected capacitive touch system. The kit is also a sophisticated development platform to facilitate implementation of projected capacitive touch screen user interfaces.

Preprogrammed firmware provided with this kit supports multi-touch, with sensors ranging from 1×1 to 13×11 XY electrode patterns. The source code is available royalty-free from www.microchip.com/mtouch for use on Microchip PIC® MCUs. The provided hardware supports up to 16×16 electrode sensors, but the current firmware only supports up to 13×11 electrode sensors.



mTouch™ Projected Capacitive Development Kit (Part # DM160211)

The mTouch Projected Capacitive Development Kit includes a 3.5in. sensor mounted on a sensor board, a projected capacitive board with the PIC16F707 MCU and fully functional firmware. The open source code supports sensors with up to 32 channels and the kit includes a graphical user interface tool that enables easy parameter adjustment.

Projected capacitive touch sensing extends resistive and existing capacitive touch sensing technology to include multi-touch and gesture sensing, enabling users to implement robust glass-front user interfaces that simplify user interaction. Typical applications include global positioning systems, thermostats, mobile handheld units and other devices that use smaller displays with a finger input.

The PIC16F707 features two 16-channel capacitive sensing modules (CSMs) that can run in parallel for increased sampling speed, and operates from a wide input voltage range of 1.8V to 5.5V, with a typical projected capacitive sensor application operating current of 1.5mA at 5V.

HOW TO ENTER

For your chance to win an mTouch Projected Capacitive Development Kit, visit **www.microchip-comps.com/EPE-ProCap**, and enter your details in the online entry form.

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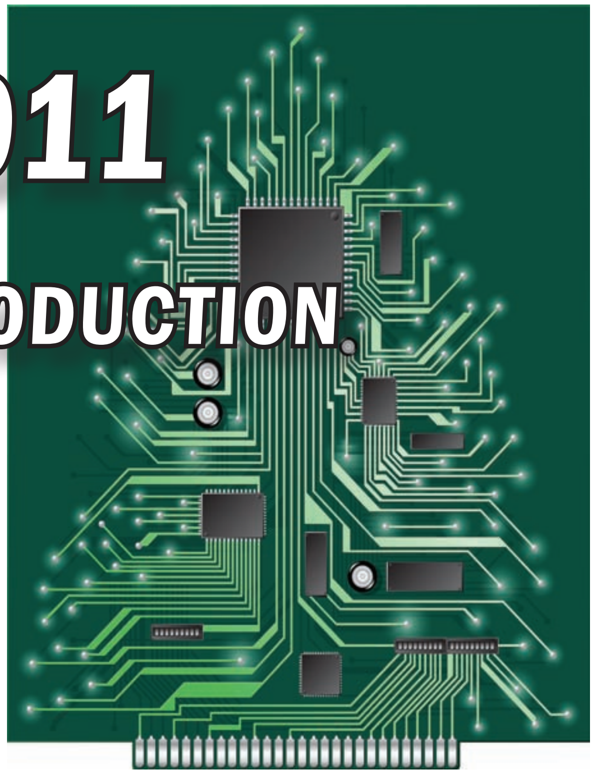
TEACH-IN 2011

A BROAD-BASED INTRODUCTION TO ELECTRONICS



Part 1: Introduction to signals in electronic circuits and systems

By Mike and Richard Tooley

Our Teach-In series is designed to provide you with a broad-based introduction to electronics. We have attempted to provide coverage of three of the most important electronics units that are currently studied in many schools and colleges in the UK. These include Edexcel BTEC Level 2 awards, as well as electronics units of the new Diploma in Engineering (also at Level 2). The series will also provide the more experienced reader with an opportunity to 'brush up' on specific topics with which he or she may be less familiar.

Each part of our Teach-In series is organised under five main headings: *Learn*, *Check*, *Build*, *Investigate* and *Amaze*. Learn will teach you the theory, Check will help you to check your understanding, and Build will give you an opportunity to build and test simple electronic circuits. Investigate will provide you with a challenge which will allow you to further extend your learning, and finally, Amaze will show you the 'wow factor'!

WE BEGIN this new *Teach-In 2011* series by introducing the signals used to convey information in electronic circuits, and the units that we use to measure the quantities in electronic circuits. We conclude this part by looking at some simple electronic circuits that you can build and test using Circuit Wizard software (see pages 54 and 71).

Signals in electronic circuits and systems

This first part of our Teach-In series will provide you with an introduction to the signals that convey *information* in electronic circuits. We will also introduce you to some of the units that are used when measuring electrical quantities, such as current, voltage and frequency. You will learn about the difference between analogue and digital signals and how to recognise signals from the shape of their waveforms.

Being able to 'read' and interpret a circuit diagram or 'schematic' is an essential skill required of every electronic technician and engineer. Many different parts and devices are used in electronic circuits, and it is important that you should be able to recognise them, both from the symbols that we use to represent them in theoretical circuit diagrams and also from their physical appearance.

Learn

Signals and signal conversion

In all forms of communication signals are used to convey information. The signals that we use in everyday life can take many forms, including flashing lights, shouting, waving our hands, shaking our heads and others forms of 'body language'. In fact, life would be very difficult without signals – think about driving a car or motorbike in heavy traffic! In this section we will look at how signals are used in electronics, how they can be converted from one form to another, and how they are measured.

In electronics, signals can take many forms including changes in voltage levels, pulses of current, and sequences of binary coded digits or *bits*. Signals that vary continuously in level are referred to as ***analogue*** signals, while those that use discrete (ie fixed) levels are referred to as ***digital*** signals. Some typical analogue and digital signals are shown in Fig.1.1. Notice how the digital signal exists only as a series of discrete voltage levels, while the analogue signal varies continuously from one voltage level to another.

Signals can also be quite easily converted from one form to another. For example, the signal from the stage microphone at a live radio broadcast will be an analogue signal at the point at which the original sound is produced (ie on stage). After appropriate processing (which might involve amplification and/or removal of noise and other unwanted sounds) it might then be converted to a digital signal for radio transmission, and then converted back to an analogue signal before being amplified and sent to the loudspeaker at the point of reception.

A device that converts an analogue signal to digital format is called an *analogue-to-digital converter* (**ADC**), while one that converts a digital signal to analogue is referred to as a *digital-to-analogue converter* (**DAC**). An electronic system that uses both analogue and digital signals is shown in Fig.1.2.

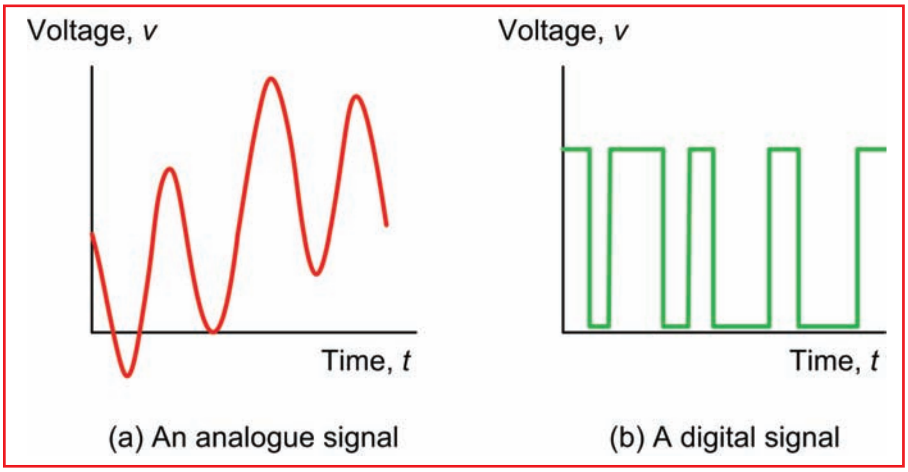


Fig.1.1. Typical analogue and digital signals

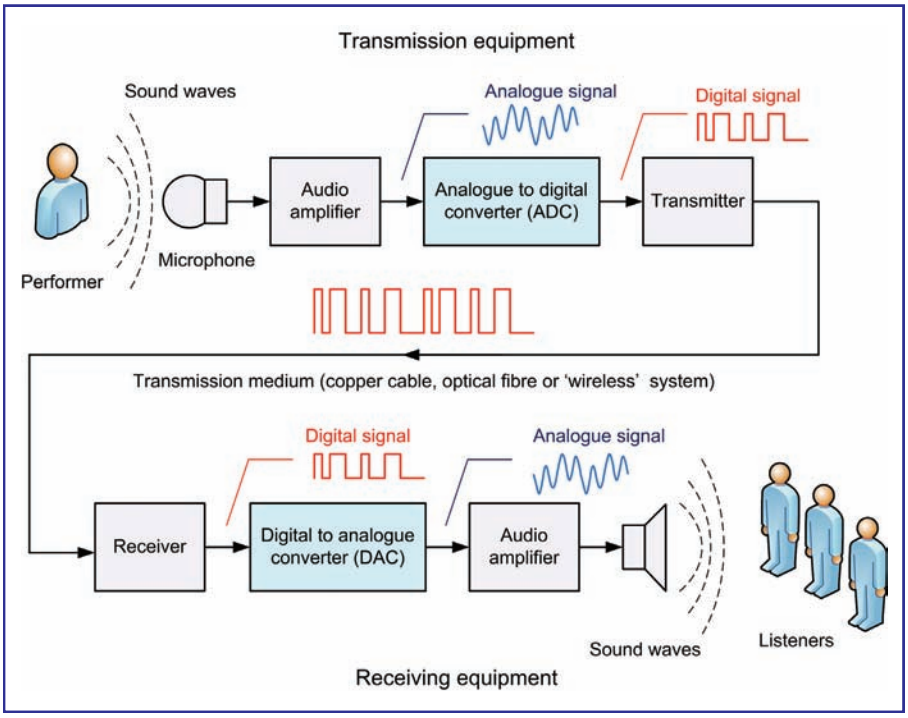


Fig.1.2. An electronic system that uses both analogue and digital signals

Electronic units

A number of units are commonly used in electronics, so we shall start by introducing some of them. Later, we will be put these units to use when we solve some simple circuit problems, but since it's important to get to know these units and also to be able to recognise their abbreviations and symbols we have summarised them in Table 1.1.

Please note!

Frequency and bit rate are very similar. They both indicate the speed at which a signal is transmitted, but bit rate is used for digital signals while frequency is used with analogue signals.

Table.1.1: Some electrical quantities and units of measurement

Parameter	***Unit***	***Abbreviation***	***Notes***
Electric potential	Volt	V	A potential of 1V (one Volt) appears between two points when a current of 1A (one Amp) flows in a circuit having a resistance of 1Ω (one Ohm). Note that electric potential is also sometimes referred to as electromotive force (EMF) or potential difference (pd)
Electric current	Ampere (or amp)	A	A current of 1A flows in an electrical conductor when electric charge is being transported at the rate of 1 Coulomb per second
Electric power	Watt	W	Power is the rate of using energy. A power of 1W (one Watt) corresponds to 1 Joule of energy being used every second
Electrical resistance	Ohm	Ω	An electric circuit has a resistance of 1Ω when a pd (see above) of 1V is dropped across it when a current of 1A is flowing in it
Frequency	Hertz	Hz	A signal has a frequency of 1Hz (one Hertz) if one complete cycle of the signal occurs in a time interval of 1s (one second)
Bit rate	Bits per second	bps	A signal has a bit rate of 1 bit per second if one complete binary digit is transmitted in a time interval of 1s

Please note!

To avoid confusion between the symbols and the abbreviations that we use for units, the former are normally displayed in italic font. For example, a capital letter V is used as both the abbreviation for voltage and for its unit symbol (the Volt). When used as a symbol in a formula it is conventionally shown in italic as *V* and when used as shorthand for volts it is shown in normal (non-italic) font as 'V'.

Multiples and sub-multiples

Unfortunately, because the numbers can be very large or very small, many of the electronic units can be cumbersome for everyday use. For example, the voltage present at the antenna of a mobile phone could be as little as one ten-millionth of a volt, or 0.0000001V. Conversely, the resistance seen at the input of an audio amplifier stage could be more than one hundred-thousand ohms, or 100,000Ω.

To make life a lot easier we use a standard range of multiples and sub-multiples. These use a prefix letter in order to add a multiplier to the quoted value, as shown in Table 1.2.

Please note!

Exponent notation is often useful when performing calculations using very large or very small numbers. You can use exponent notation by pressing the exponent (E) or engineering (ENG) button on your calculator.

Converting to/from multiples and sub-multiples

Converting to and from multiples and sub-multiples is actually quite easy, as the following examples show:

Example 1

Convert 7,240Hz to kHz. To do this you just need to move the decimal point *three* places to the *left*. This is the same as dividing by 1,000 (because there are 1,000Hz in 1kHz).

Moving the decimal point three places to the left tells us that 7,240Hz = 7.240kHz = 7.24kHz.

Example 2

Convert 2,200,000Ω to MΩ. To do this you need to move the decimal point *six* places to the *left*. This is the same as dividing by 1,000,000 (because there are 1,000,000Ω in 1MΩ).

Moving the decimal point six places to the left tells us that 2,200,000Ω = 2.2MΩ.

Example 3

Convert 0.625V to mV. To do this you need to move the decimal point *three* places to the *right*. This is the same as multiplying by 1,000 (because there are 1,000mV in 1V).

Moving the decimal point three places to the right tells us that 0.625V = 625mV.

Example 4

Convert 14,400kbps to Mbps. To do this you need to move the decimal point *three* places to the *left*. This is the same as dividing by 1,000 (because there are 1,000kbps in 1Mbps).

Moving the decimal point three places to the left tells us that 14,400kbps =14.4Mbps.

Please note!

Multiplying by 1,000 is equivalent to moving the decimal point three places to the right, while dividing by 1,000 is equivalent to moving the decimal point three places to the left. Similarly, multiplying by 1,000,000 is equivalent to moving the decimal point six places to the right, while dividing by 1,000,000 is equivalent to moving the decimal point six places to the left.

Waveforms and waveform measurement

A graph showing the variation of voltage or current present in a circuit

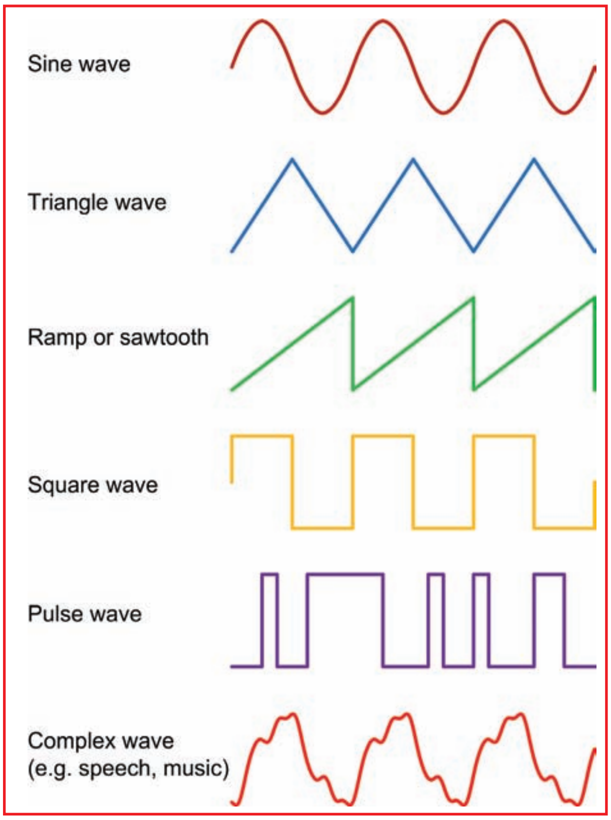


Fig.1.3. Some common waveforms

Table.1.2: Some common multiples and sub-multiples

Multiple	*Exponent notation*	*Prefix*	*Abbreviation*	*Example*
×1,000,000,000	$\times 10^{9}$	Giga	G	1.2GHz (1,200 million Hertz)
×1,000,000	$\times 10^{6}$	Mega	M	2.2MΩ (2.2 million Ohms)
×1,000	$\times 10^{3}$	Kilo	k	4kbs (4,000 bits per second)
×1	$\times 10^{0}$	None	none	220Ω (220 Ohms)
×0.001	$\times 10^{-3}$	Milli	m	45mV (0.045 Volts)
×0.000,001	$\times 10^{-6}$	Micro	μ	33µA (0.000033 Amps)
×0.000,000,001	$\times 10^{-9}$	Nano	n	450nW (0.00000045 Watts)

is known as a ***waveform***. Waveforms show us how voltage or current signals vary with time. There are many common types of waveform encountered in electronic circuits, including *sine* (or sinusoidal), *square*, *triangle*, *ramp* or *sawtooth* (which may be either positive or negative going), and *pulse*.

Complex waveforms, like speech and music, usually comprise many different signal components at different frequencies. Pulse waveforms are often categorised as either repetitive or non-repetitive (the former comprises a pattern of pulses that repeats regularly, while the latter comprises pulses which each constitute a unique event). Some common waveforms are shown in Fig.1.3.

Frequency

The frequency of a repetitive waveform is the number of cycles of the waveform which occur in unit time (ie one second). Frequency is expressed in Hertz (Hz), and a frequency of 1Hz is equivalent to one cycle per second. Hence, if a voltage has a frequency of 50Hz, 50 cycles of it will occur in every second.

Periodic time

The periodic time (or period) of a waveform is the time taken for one complete cycle of the wave (see Fig.1.4). The relationship between periodic time and frequency is thus:

$t = 1 / f$ or $f = 1 / t$

where t is the periodic time (in s) and f is the frequency (in Hz).

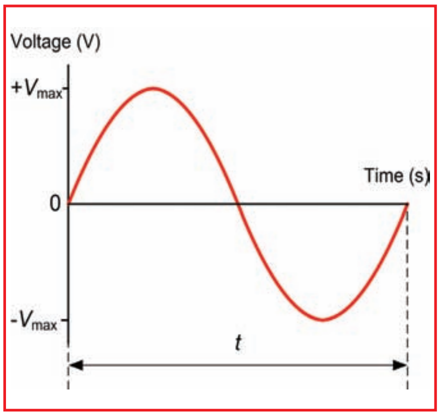


Fig.1.4. One cycle of a sinewave voltage showing its periodic time

Example 5

A waveform has a frequency of 50Hz. What is the periodic time of the waveform?

Here we must use the relationship $t = 1 / f$, where f = 50Hz.

Hence, $t = 1 / 50 = 0.02$s (or 20ms)

Example 6

A waveform has a periodic time of 4ms. What is its frequency?

Here we must use the relationship $f = 1 / t$, where t = 4ms or 0.004s.

Hence, $f = 1 / 0.004 = 250$Hz.

Amplitude

The amplitude (or *peak value*) of a waveform is a measure of the extent of its voltage or current excursion from the resting value (usually zero). The *peak-to-peak* value for a wave, which is symmetrical about its resting value, is twice its peak value (see Fig.1.5). These units are usually more convenient to use when taking measurements from a waveform display.

Pulse waveforms

When describing rectangular and pulse waveforms we use a different set of parameters (see Fig. 1.6). These include:

On time, t_{on}

This is the time for which the pulse is present at its maximum amplitude. This is sometimes referred to as the '*mark time*'.

Note that when a pulse is not perfectly rectangular (ie, when it takes some time to change from one level to the other), we define the off time as the time for which the pulse amplitude remains above 50% of its maximum value.

Off time, t_{OFF}

This is the time for which the pulse is not present (ie, zero voltage or current). This is sometimes referred to as the '*space time*'.

Note that, when a pulse is not perfectly rectangular (and takes some time to change from one level to another), we define the off time as the time for which the pulse amplitude falls below 50% of its maximum value.

Pulse period, t

This is the time for one complete cycle of a repetitive pulse waveform. The periodic time is thus equal to the sum of the on and off times (but once again, note that this is only valid if the pulse train is repetitive and is meaningless if the pulses occur at random intervals).

When a pulse train is not perfectly rectangular, the pulse period is measured at the 50% amplitude points.

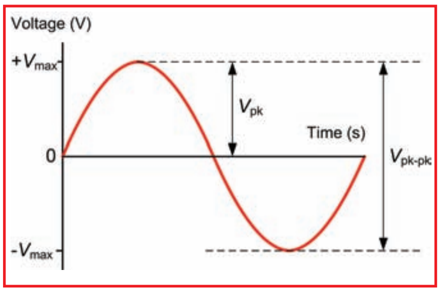


Fig.1.5. One cycle of a sinewave voltage showing its peak and peak-to-peak values

Pulse repetition frequency, prf

The pulse repetition frequency (prf) is the reciprocal of the pulse period. Hence:

$prf = 1 / t = 1 / (t_{ON} + t_{OFF})$

Mark to space ratio

The mark to space ratio of a pulse wave is simply the ratio of the on to off times. Hence:

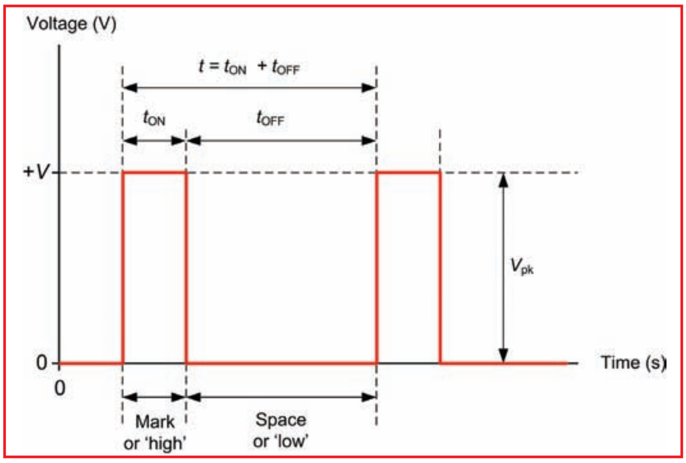


Fig.1.6. A pulse waveform showing 'on' and 'off' times

Mark to space ratio = $t_{ON} : t_{OFF}$

Note that, for a perfect square wave the mark to space ratio will be 1:1, because $t_{ON} = t_{OFF}$

Duty cycle

The duty cycle of a pulse wave is the ratio of the on time to the on plus off time (and is usually expressed as a percentage). Hence:

Duty cycle $= t_{ON} \; / \; (t_{ON} + t_{OFF}) \times 100\% \; = \; t_{ON} \; / \; t \; \times 100\%$

For a perfect square wave, the duty cycle will be 50%.

Cells, batteries and power supplies

Cells and batteries provide the power for a wide range of portable and hand-held electronic equipment. There are two basic types of cell: *primary* and *secondary*.

Primary cells produce electrical energy at the expense of the chemicals from which they are made and once these chemicals are used up, no more electricity can be obtained from the cell. An example of a primary cell is an ordinary 1.5V AA alkaline battery.

In secondary cells, the chemical action is reversible. This means that the chemical energy is converted into electrical energy when the cell is discharged, whereas electrical energy is converted into chemical energy when the cell is being charged. An example of a secondary cell is a 1.2V AA nickel cadmium (NiCad) battery.

In order to produce a battery, individual cells are usually connected in series with one another, as shown in Fig.1.9. The voltage produced by a battery with n cells will be *n* times the voltage of one individual cell (assuming that all of the cells are identical). Furthermore, each cell in the battery will supply the same current.

Series connected cells are often used to form batteries. For example, the popular PP3, PP6 and PP9 batteries are made from six 'layered' 1.5V primary alkaline cells, which are effectively connected in series. A 12V car battery, on the other hand, uses six 2V lead-acid secondary cells connected in series.

Where an electronic circuit derives its power from an AC mains supply, we sometimes show the supply as a box with two terminals (one marked positive and one marked negative). Treating the power supply as a separate unit helps keep the circuit simple. If the power supply fails we can simply replace the entire unit in much the same way as we would replace a set of exhausted batteries.

Fig.1.7. Some typical cells and batteries used in electronic equipment

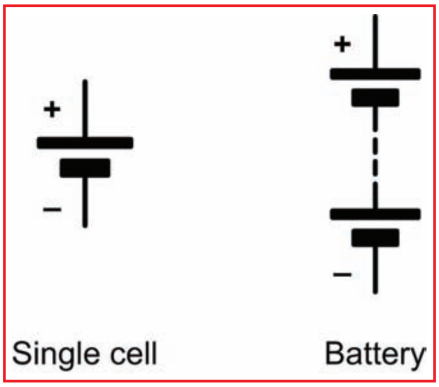


Fig.1.8. Symbols for cells and batteries

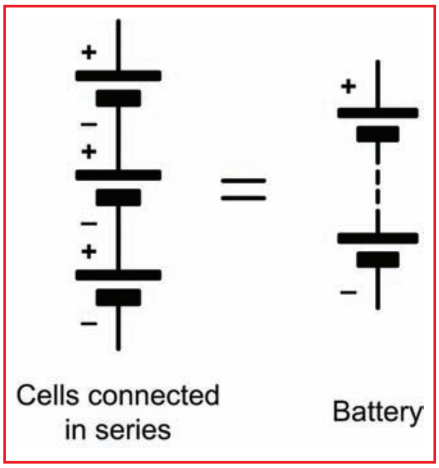


Fig.1.9. Series arrangement of cells

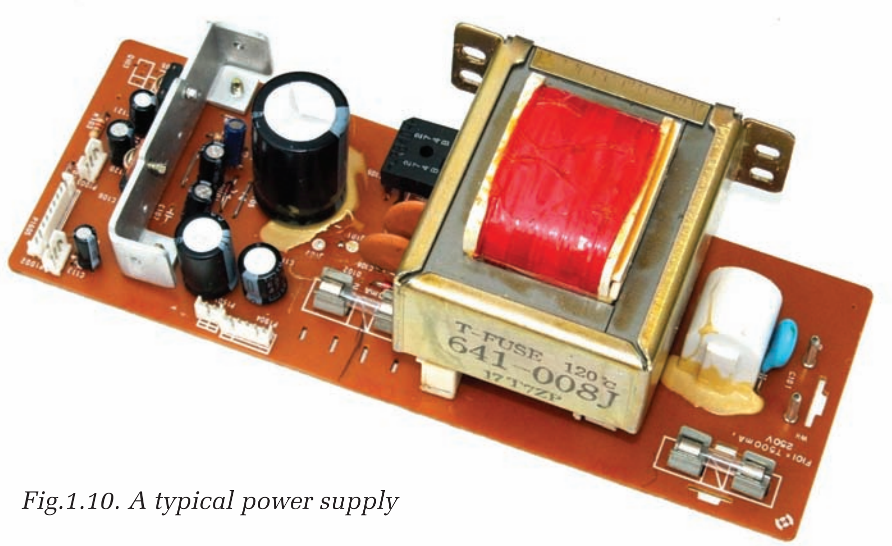


Fig.1.10. A typical power supply

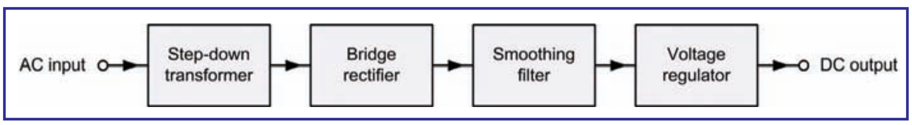


Fig.1.11. A block schematic representation of the power supply in Fig.1.10

A typical power supply which has an AC mains input and DC output is shown in Fig.1.10. Fig.1.11 shows how we can represent the power supply using a simple *block schematic diagram*. Note that we have not shown any switches, fuses or indicators in this diagram!

Please note!

We refer to the output voltage produced by a battery or a power supply as an electromotive force (EMF). Electromotive force is measured in volts, V. In contrast, we refer to the voltage drop across an electronic component (such as a resistor or capacitor) as a potential difference (pd). Potential difference is also measured in volts (V).

The best way to distinguish between EMF and pd is to remember that EMF is the 'cause' and pd is the 'effect'.

Check – How do you think you are doing?

Short answer questions

1.1. Explain the difference between analogue and digital signals.

1.2. List the units used for each of the following electrical quantities:

(a) current

(b) potential

(c) power

(d) resistance

(e) frequency

(f) bit rate.

1.3. Explain what is meant by each of the following abbreviations:

(a) mV

(b) kHz

(c) µA

(d) MHz

(e) kΩ

(f) nW

(d) kbps.

1.4. An amplifier requires an input signal of 0.055V. Express this in mV.

1.5. An ADC operates at a bit rate of 125kbps. Express this in Mbps.

1.6. A current of 75μA flows in a resistor. Express this in mA.

1.7. A radio signal has a frequency of 0.465MHz. Express this in kHz.

1.8. A portable CD player uses a battery which has four 1.5V cells connected in series. What EMF does this battery supply?

1.9. Explain the difference between EMF and pd.

1.10. Explain the difference between primary cells and secondary cells.

Long answer questions

1.11. Fig.1.12 below shows an electronic system that uses both analogue and digital signals. Take a careful look at the diagram and see if you can understand how it works before answering the following questions:

(a) Explain the purpose of the system

(b) At which points (A, B, C etc.) do the signals exist in digital form and at which points do they exist in analogue form?

(c) What form do the signals have when they are present in the wireless (radio) link?

(d) Can you suggest any advantages and/or disadvantages of the system?

1.12. Fig1.13 shows a waveform diagram.

(a) What type of waveform is shown?

(b) What is the amplitude of the waveform?

(c) What is the period of the waveform?

(d) What is the repetition frequency of the waveform?

(e) What is the mark-to-space ratio of the waveform?

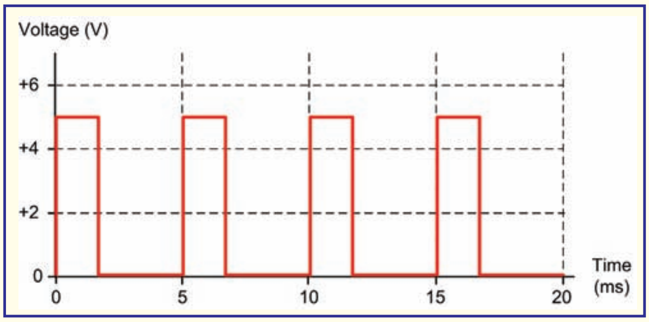


Fig.1.13. See Question 1.12

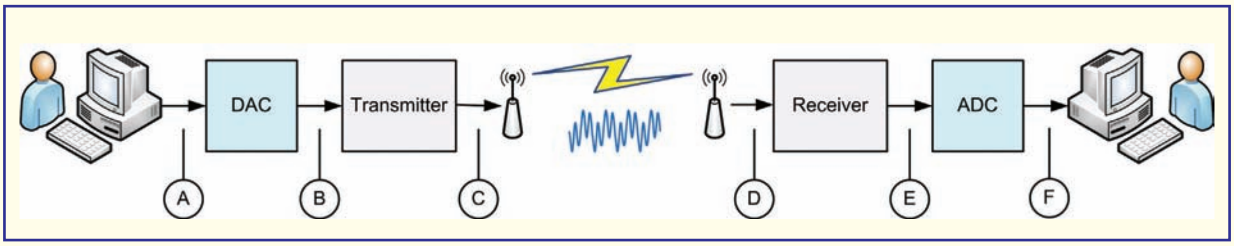


Fig.1.12. See Question 1.11

Build – The Circuit Wizard way

ONE of the problems with electronics is simply the amount of kit that you need to get started. Even a basic starter set-up could run in to hundreds of pounds; soldering iron, hand tools, circuit board, wires, leads, components, test equipment – it all adds up! Therefore, the 'Build' section of our Teach-In series is going to focus around using Circuit Wizard, a really great piece of circuit simulation software that runs on your Windows PC.

In this way, you'll have access to literally thousands of components, a full range of 'virtual test equipment' along with real-time simulation and tools to help you actually visualise the operation of your circuits. There's also the ability to build breadboard circuits and convert your circuits into a printed circuit board (PCB) design that can then be manufactured. We really feel that it's the ideal way to get started with electronics, so much so that, with the next issue of *EPE*, we will give away a *free* CD-ROM containing a 'demo' version of the Circuit Wizard.

Simulation

Students of electronics are often confused by the fact that you can't actually see what's going on inside a circuit. In a mechanical machine it's easy to see things moving and working, but we have none of these visual clues when working on an electronic circuit.

Computer simulation neatly overcomes this problem by providing a visual representation of what's going on under the surface. This might include the flow of current in wires, the voltage at various points in a circuit, or the charge present in a capacitor.

In industry, the use of software for simulation, design and manufacture of electronic products is the norm. Indeed, being able to make effective use of software tools is now a key skill for any aspiring electronic engineer or hobbyist.

A standard licence for Circuit Wizard costs around £60 and can be purchased from the editorial office of EPE – see the UK shop on our website (**www.epemag.com**). Further information can be found on the New Wave Concepts website; **www.new-wave-concepts.com**. The developer also offers an evaluation copy of the software that will operate for 30 days, although it does have some limitations applied, such as only being able to simulate the included sample circuits and no ability to save your creations, this is the software that will be *free* with *EPE* next month. However, if you're serious about electronics and want to follow our series, then a copy of Circuit Wizard is a really sound investment.

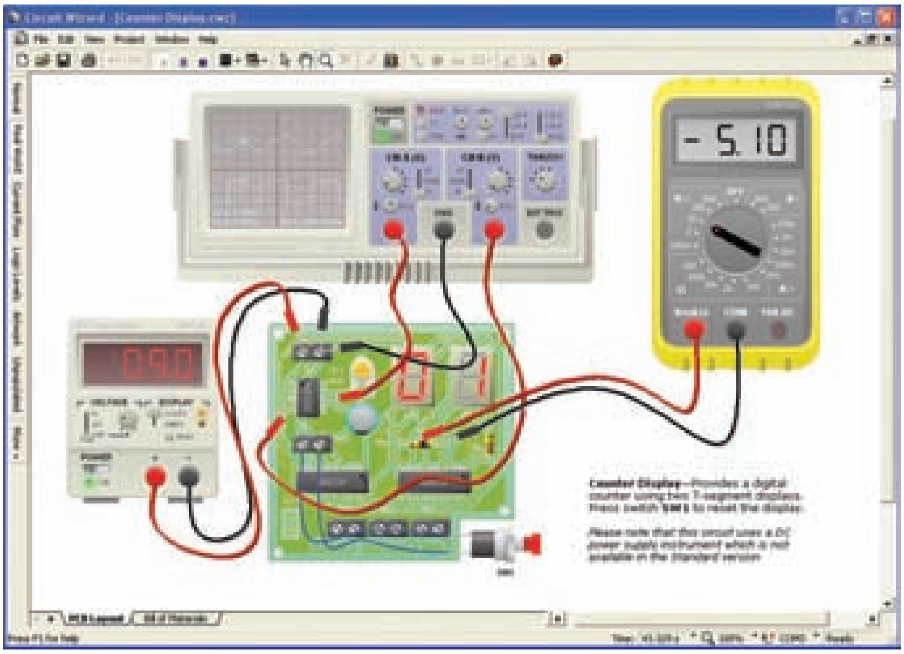


Fig.1.14. Circuit Wizard screenshot showing the use of 'virtual instruments'

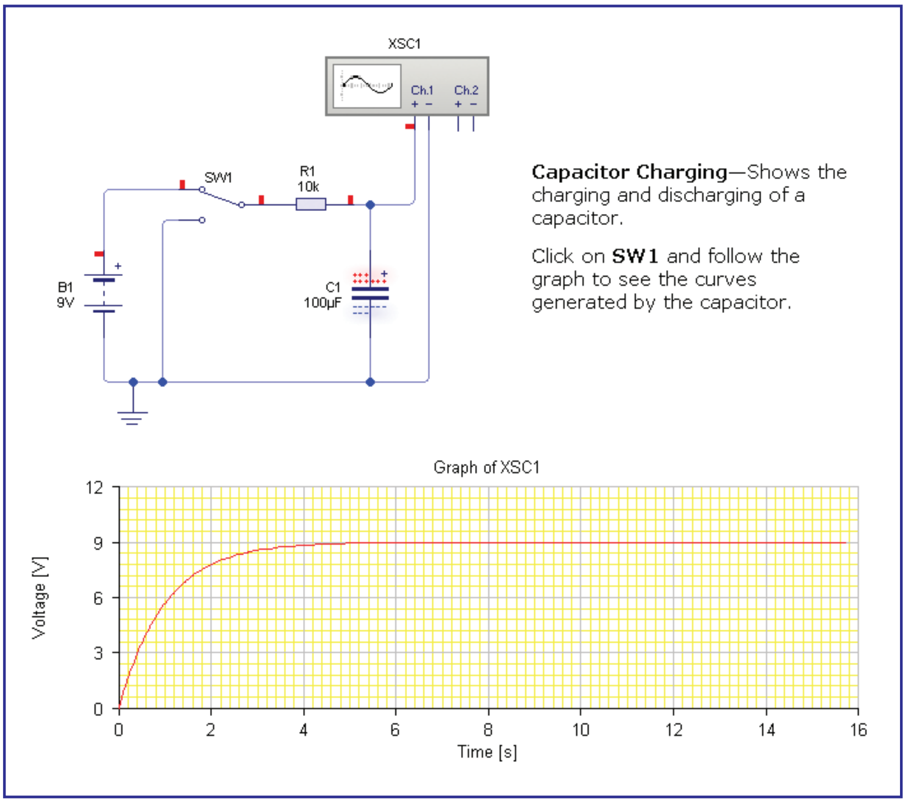


Fig.1.15. A capacitor charging circuit showing charge building up on the plates, voltage levels and a graphical plot of voltage against time

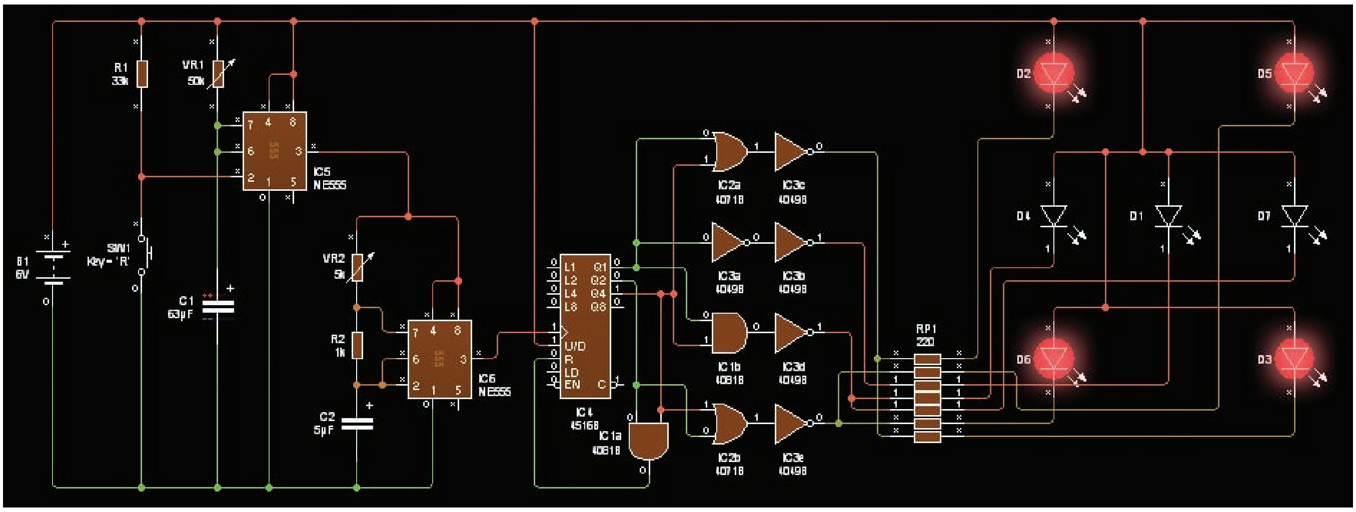


Fig.1.16 A logic-based electronic dice in 'logic view' showing digital signal levels at each point in the circuit

In this instalment, we're going to look at installing and getting started with Circuit Wizard. In future months we will be using the software to investigate the theory and circuits that you will meet in 'Learn'. We'll also develop electronic devices and use Circuit Wizard to design and produce PCBs so that you can make the real thing!

Installation

Installation of Circuit Wizard is very straightforward, and it's a surprisingly small installation for what is such a powerful piece of software. Our install process took no more than quarter of an hour from start to finish. During the installation process you'll be asked to enter a licence key which will be supplied with your install disc.

When you run Circuit Wizard for the first time you will be asked to obtain a release code, which can be done over the 'phone or via the developer's website where the release code is then subsequently e-mailed to you. This needs to be done within a 60-day window or the software will cease to load.

First looks

The user interface is both clean and intuitive. The main white drawing area fills most of the screen, with the standard Windows menus and toolbar across the top. A tabbed pane on the right-hand side of the screen presents a 'Getting Started' menu, where you can access various samples/tutorials and gain help.

Clicking the 'Gallery' tab exposes an extensive library of components and test equipment. Tabs on the far left of the screen allow you to see your circuit in various different 'views'. These are designed to help you see what's actually going on in your circuits by colouring and/or animating the circuit diagram to show voltages/currents.

This is a really nifty feature, allowing you to actually see electronics in action. There are a number of preset views or you can create your own to suit. Along the bottom of the screen a row of tabs allows you to change between different pages of your design.

'Drawing' is where you would actually enter and simulate a circuit, 'PCB Layout' is where you would produce a PCB design (as well as working with virtual test equipment and breadboards). Finally, 'Bill of Materials' generates an inventory/costing of the components used in your circuit.

Finding your way around

By far the best way to get started with Circuit Wizard is to follow the guided tour screen videos and experiment with the sample circuits provided. All of these are directly accessible from the 'Getting Started' page in the right-hand pane (click on

Fig.1.17. Circuit Wizard's Gallery of components and test equipment

The Circuit Wizard way

the 'Assistant' tab if the circuit gallery view is shown).

The screen videos explain the basic operation of the software but lack sound, with only written descriptions appearing on the screen; this does make for slow progress. If you're a confident computer user you may want to just jump straight in and explore over fifty sample circuits that are included and get to know the software hands-on.

Fig.1.18. Circuit Wizard provides a good selection of starter materials

The sample circuits are split by complexity into three folders; simple, basic and advanced. Each of these is then further divided into sub-categories, which really showcase the extensive features of the software. The sample circuits are excellent and contain instructions on how to test out the circuit – they're also really educational, so you might even learn something about electronics as you discover the software too!

In next month's instalment, we'll be showing you how to enter and test some simple circuits that will be underpinned by the theory covered in our 'Learn' section. Until then, you might like to get yourself a copy of Circuit Wizard and have a play! If you're really keen to get stuck in, check out our *Teach-In 2011* website at **www.tooley.co.uk/teach-in**, where you can download some further examples.

Fig.1.19. A typical bench oscilloscope

Investigate

WAVEFORMS are usually displayed using an instrument called an oscilloscope. You will learn more about this instrument later in the series. Oscilloscopes can be standalone test instruments (see Fig.1.19) or they can be virtual instruments that use a PC's in-built signal processing capabilities (eg, the analogue-to-digital converter in a PC sound card).

Fig.1.20 shows a typical virtual instrument display obtained by using a soundcard oscilloscope program. The program receives its data from the computer's sound card with a sampling rate of 44.1kHz and a resolution of 16-bits. The data source can be selected by the PC's own sound card controls (eg, microphone, line input or wave). The frequency range of the instrument depends on the performance of the computer's sound card, but is typically accurate over the range 20Hz to 20kHz.

The oscilloscope also contains a simple signal generator producing sine, square, triangle and sawtooth waveforms in the frequency range from 0 to 20kHz. These signals are available at the speaker output of the sound card.

Take a careful look at Fig. 1.20 and use it to answer the following questions:

(a) What type of waveform is shown?

(b) What total time interval is displayed on the screen: (Hint: look at the horizontal scale)

(c) What settings are used for the vertical and horizontal scales on the oscilloscope display?

(d) What is the greatest positive voltage present in the waveform sample?

(e) What is the greatest negative voltage present in the waveform sample?

(f) What is the overall peak-peak voltage of the waveform?

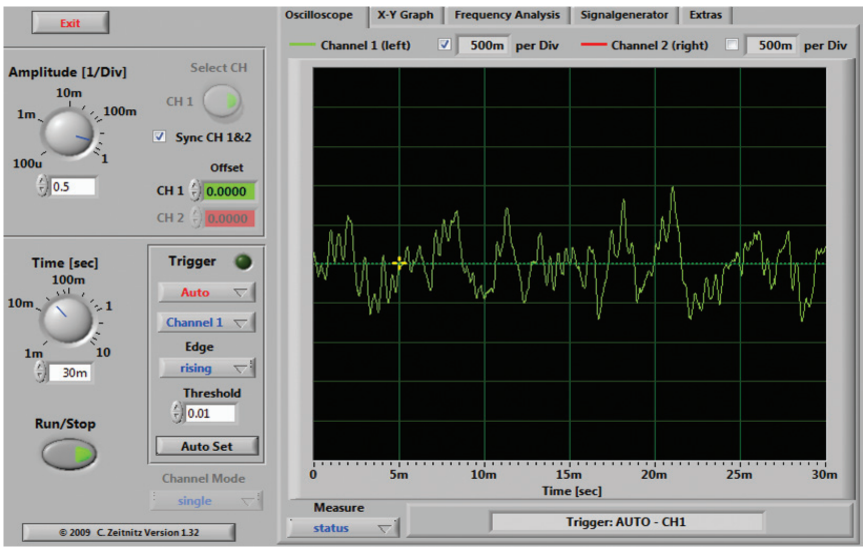


Fig.1.20 See the Investigate questions

Answers to Questions

1.1. Analogue signals vary continuously in voltage and current whilst digital signals can only exist in discrete levels of voltage or current.

1.22. (a) Ampere, (b) Volt, (c) Watt, (d) Ohm, (e) Hertz, (f) bits per second.

1.3. (a) millivolt, (b) kilohertz, (c) microamp, (d) megahertz, (e) kilohm, (f) nanowatt, (g) kilobits per second.

1.4. 55mV

1.5. 0.125Mbps

1.6. 0.075mA

1.7. 465kHz

1.8. 6V

1.9. EMF is used to describe the output voltage produced by a battery or power supply. Potential difference is used to describe the voltage drop that appears across a component such as a resistor or capacitor.

1.10. Primary cells produce electrical energy from a non-reversible chemical reaction and must be disposed of when exhausted. Secondary cells make use of a reversible chemical reaction and can be recharged and used again.

1.11. (a) Wireless data link between computer systems, (b) A digital; B analogue; C analogue; D analogue; E analogue; F digital, (c) Sinewave radio frequency with superimposed (modulated) signal information, (d) Disadvantages: lack of security compared with systems linked by cable, may suffer from interference to/from other nearby wireless systems; Advantages: simple to install, does not need permanent cabling.

1.12. (a) pulse wave, (b) 5V, (c) 5ms, (d) 200Hz, (e) 1:2

Amaze

Download a copy of the Soundcard Oscilloscope software and investigate the operation of the program using some typical signals applied to the microphone or auxiliary inputs of a PC. The software is available from Christian Zeitnitz's website: **http://www.zeitnitz.de/Christian/scope_en**

Next month

In next month's *Teach-In 2011* we shall be looking at resistors and capacitors. Examples of these two passive components are found in almost every electronic circuit. Furthermore, when used together, these two components form the basis of a wide range of electronic timing and delay circuits.

We shall be investigating the behaviour of these circuits using Circuit Wizard.

For more information, links and other resources please check out our Teach-In website at:
www.tooley.co.uk/teach-in

BY IAN BELL

Fast Fourier Transform (FFT) and LTspice

FOR the past couple of issues we have covered the topic of Total Harmonic Distortion (THD) in response to a question from frequent *EPE Chat Zone* contributor **741**. We have looked at the definition of THD and related characteristics, and the theory behind these. We also looked at ways to measure THD, which was part of 741's original question.

As readers of the previous THD articles will have seen, the frequency spectrum of a signal is important to the understanding of THD, and can be used directly to calculate THD. Spectra are an important tool for studying signals and have many uses, not just the calculation of THD.

The spectra which we drew to illustrate our THD discussion were straightforward and clear-cut. However, when using real spectrum analysers and simulators to observe spectra, the situation is rarely so simple. This leads us to the second part of 741's question about measuring and observing a signal's spectrum using a Fast Fourier Transform (FFT).

On LTspice I placed an ideal sine generator, then chose View/FFT. I noticed the wide 'skirts' leading up to the peak at the sine frequency. I wondered what determines the sharpness of the peak.

Spicing it up

Before getting to the specifics of 741's question we will take a brief look at the SPICE simulation, for the benefit of readers who may not be very familiar with it. We will then look at the general concepts behind calculating a spectrum, because some understanding of this will make the settings in the LTspice dialog (which controls the display of an FFT) much more meaningful and easier to use.

This will also help with understanding the errors and approximations which can occur in a spectrum, which are at the heart of 741's question. Next month, we will look in more detail at the specifics of using LTspice to display spectra.

Spice is an acronym for Simulation Program with Integrated Circuit Emphasis. It was originally developed in the early 1970s at the University of California, Berkeley (see **http://bwrc.eecs.berkeley.edu/Classes/IcBook/SPICE/** and **http://embedded.eecs.berkeley.edu/pubs/downloads/spice/index.htm**) and is still available from there. Spice is now a *de facto* industrial standard for computer-aided electronic circuit analysis with many commercial versions based on the original work from Berkeley.

Although Spice was initially developed for analysing ICs, it can be applied to any electrical network (of resistors, capacitors, transistors etc). It was originally an analogue circuit simulator, but modern versions allow logic gates and more complex digital functions to be included, allowing digital and mixed-signal (analogue and digital) circuits to be simulated. However, Spice would not normally be used for large fully digital circuits.

Spice simulation

To simulate a circuit with Spice you have to first draw the schematic using the simulator's schematic capture software. Alternatively, a text description of the circuit (a netlist) could be used, as was the case in early versions of Spice.

However, your circuit alone is not enough for a simulation – you have to define what happens at its inputs (stimulus signals) and outputs (eg, appropriate loads). You also need to specify what kind of simulation/analysis to perform and provide the necessary parameters (eg, how much time to spend simulating). We will be looking at the use of transient simulation and the FFT analysis mentioned by 741.

Professional Electronics Computer Aided Design (ECAD) software can be very expensive, but fortunately for the amateur on a tight budget there are a number of free Spice simulators available. The LTspice simulator to which 741 refers is one of these. It can be downloaded in its full form from the Linear Technology website: **www.linear.com/designtools/software/**.

LTspice is optimised for simulating switched-mode power supplies, which form an important part of Linear Technology's product line. However, it also does a fine job with 'ordinary' Spice simulation tasks. Linear Technology produced the simulator because many other Spice simulators struggled with

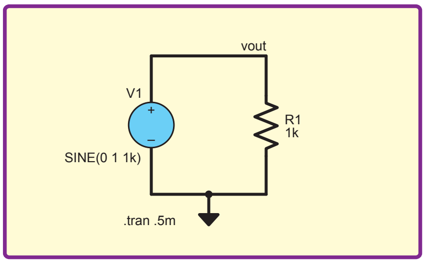


Fig.1. A very simple circuit can be used to get a spectrum (FFT) analysis in Spice to investigate the effect of various simulation and analysis parameters

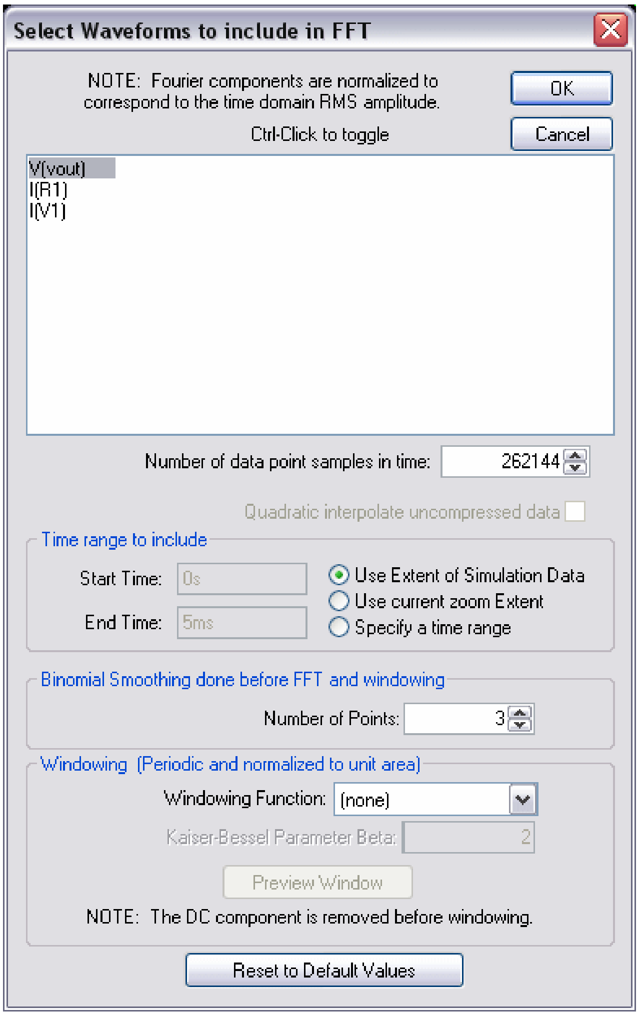


Fig.2. The FFT dialog in LTspice; understanding the parameters set in this dialogue is necessary to get the best out of spectral analysis

switch-mode circuits, due to the complexity of the waveforms involved. It comes with a set of models of Linear Technology devices, including op amps (over 300 of them) and regulators, but other 'standard' Spice models will work with it if you have them available.

Easy to use

LTspice has an easy-to-use user interface and it is very straightforward to change something in a circuit and run the simulation again to see what difference it makes. Linear Technology's philosophy in designing the simulator was to allow a lot of flexibility, while providing sufficient warning messages if circuits are badly flawed. However, analogue circuit simulation is not a mindless point and click activity. Spice simulations can sometimes produce apparently wrong or misleading results without producing any error messages or warnings.

This is a problem if the user does not understand its limitations, how to interpret the results, or how to use the right options and settings to get the best results. 741's question is an example of this – FFT analysis may produce apparently strange results if the data or settings are insufficient or inappropriate.

Minimal circuit

A very minimal circuit can be used to experiment with the FFT function in LTspice. All you need is a voltage source and a resistive load, as shown in Fig.1. The spectrum of the voltage across the load can be displayed and the various parameters of the simulation and the way the FFT is calculated can be varied to see what effect they have on the spectrum displayed. The voltage source can be switched between a sinewave and a square wave to create a simple, or more complex, true spectrum, as required.

To get a spectrum like the one 741 is asking about, do the following. Enter the schematic shown in Fig.1, right click on the voltage source, click on 'Advanced' and select a sine function in the voltage source dialog. Set the amplitude to 1 and the frequency to 1kHz and click OK to close the dialog.

Use the 'Edit Simulation Cmd' function from the Simulation menu and select transient simulation. Enter a stop time of 5m and click OK. Run the simulation and add vout as a trace on the waveform window. You should see five cycles of a 1kHz sinewave. Right click on the waveform and select View -> FFT. This will open the FFT dialog (see Fig.2). Check vout is selected and click OK.

The spectrum produced will be like that shown in Fig.3 (this shows only part of the default spectrum displayed). We would expect a very narrow peak at 1kHz and nothing at other frequencies. There is a peak at 1kHz, but, as indicated by 741, it is much wider than expected, ranging from 800Hz to 1.2kHz. This is due to spectral leakage, which we will discuss later.

There is also a lot of 'noise' at other frequencies, much of which is due to the fact that LTspice compresses the waveform data from the simulation. A better spectrum is obtained if the compression is disabled, we will discuss this next month.

In order to understand how to get the most out of a spectrum (FFT) analysis in Spice, we need to be aware of a few things about how spectra are produced from measured or simulated data, and the errors and approximations which are inherent in this process.

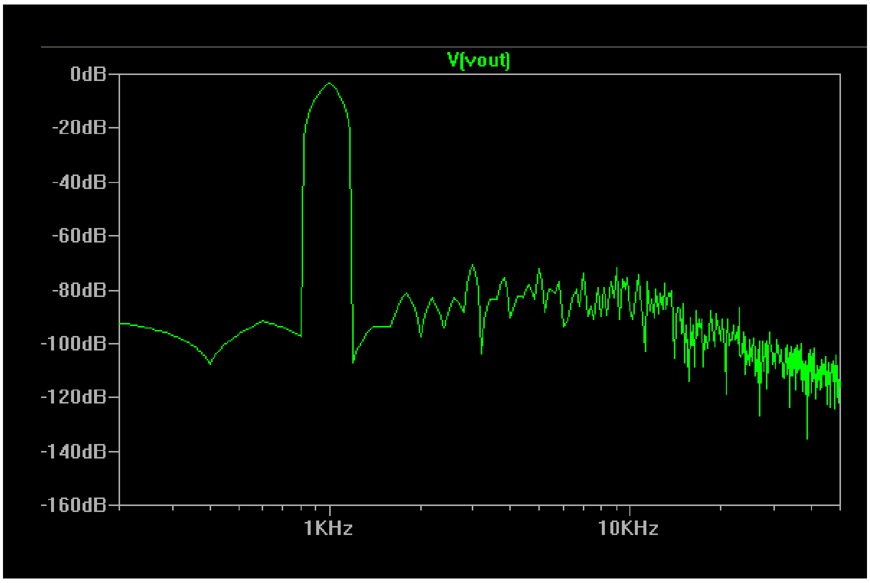


*Fig.3. The influence of things such as data compression and spectral leakage result in a spectrum which is **not** very close to that expected for a pure sinewave*

Fourier series

As we mentioned in the previous article on THD, one of the mathematical concepts underlying the spectrum is the Fourier series. Any *periodic* waveform can be formed from a sum of sinewaves at different amplitudes, and a plot of the amplitude of these frequencies (against frequency) is called a spectrum. More specifically, a Fourier series is a set of frequencies which are multiples of a fundamental frequency. A frequency which is n times the fundamental is called the nth harmonic. The only periodic waveform which has only one frequency in its spectrum is the sinewave itself.

The Fourier series is a powerful mathematical tool for understanding and analysing signals, but it has the limitation that it only applies to periodic signals, of which sinewaves and square waves are simple well known examples. More generally, a periodic waveform is one for which we can draw a portion of the waveform of length, T, in time and the whole waveform consists of this shape repeated continuously. T is called the period of the waveform. Many real-world signals are not periodic (eg, voice signals and one-off pulses).

We will not go into the details of the mathematics here, but it is possible to extend the idea of the Fourier series to cover non-periodic waveforms. Briefly, what happens is that instead of the spectrum being a set of individual discrete frequencies (the harmonics we mentioned above), we get a spectrum which is a continuous function of frequency.

Most readers will be familiar with the idea of an analogue signal or waveform – one that varies continuously with time, and which can take any value (within a specific range). At each instant in time an analogue signal has a defined value, which may be different from the value at any other instant. Similarly, the spectrum of a non-periodic signal is 'analogue' – the amplitude varies continuously with frequency and may have a different value at each and every frequency.

Fourier transform

The mathematics which defines the continuous spectrum of a signal is called the Fourier transform. Thus, if we have a signal we are interested in, in theory we can apply the Fourier transform to the signal to find its spectrum. There is, however, another practical difficulty here. We do not know (in general) the mathematical function which represents our signal; but this is the 'input' required by the Fourier transform. Looked at another way, we would need an infinite number of measurements, even for an arbitrarily small section of signal, (or simulation data points) in order to find the spectrum.

In practice, we have to measure (sample) the signal (or perform the simulation) at finitely spaced time points, and use just this data. As the Fourier transform is defined for continuous signals, we have to again adapt the mathematics to account for this limitation. For sampled signal data we can use the Discrete Fourier Transform (DFT) to find the spectrum.

Using the DFT we are able to build hardware, or write software, which will find the spectrum of an arbitrary signal. However, there are still a couple of limitations to consider. First, we can only consider the signal for a limited time, whereas the DFT is defined in terms of an infinite number of sample points (over infinite time). This is not the same problem as with the Fourier transform, because a finite section of waveform is now represented by a finite number of sample points.

By using a limited number of samples we do not break the technique, but we do reduce the accuracy of the spectrum we produce; we will look at this in more detail in a moment. The number of sample points is one of the parameters which can be set by the user when calculating a spectrum using LTspice.

The second limitation is that we can only perform the DFT calculation a finite number of times. So practically, we can only find a discrete spectrum, rather than the true continuous spectrum.

Each DFT calculation provides us with a single frequency point in our spectrum (amplitude at that particular frequency) – plotted directly, the spectrum will

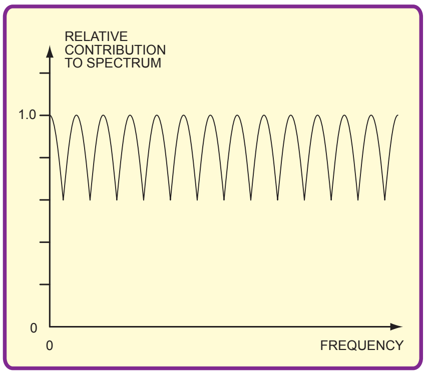


Fig.4. Variation in weighting of contribution to spectrum with frequency (the picket fence effect)

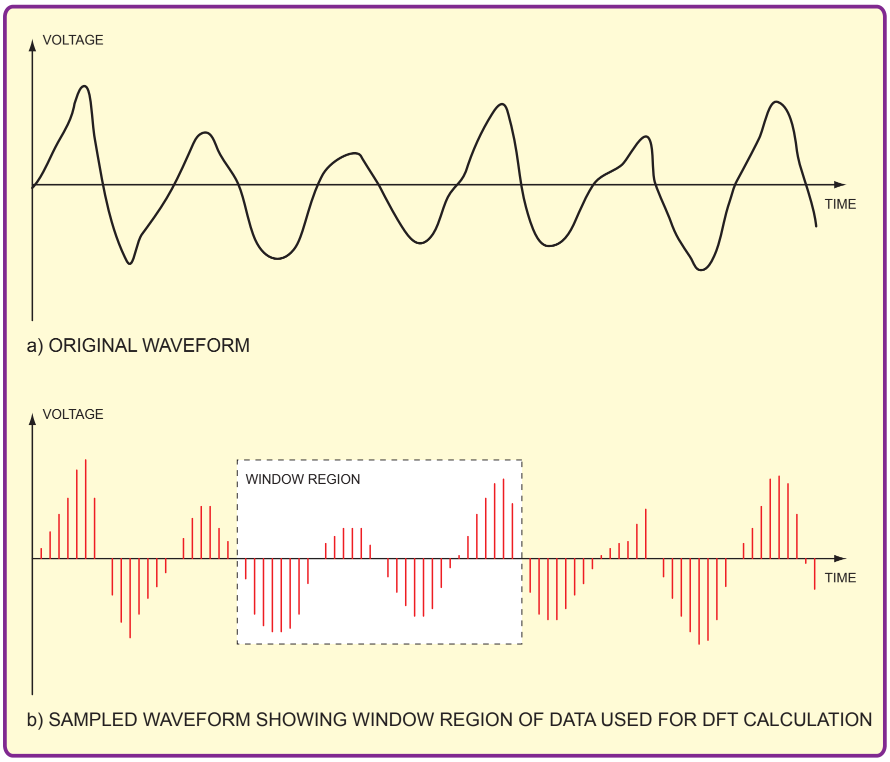


Fig.5. The data used to display a spectrum is a window of samples of the original analogue waveform

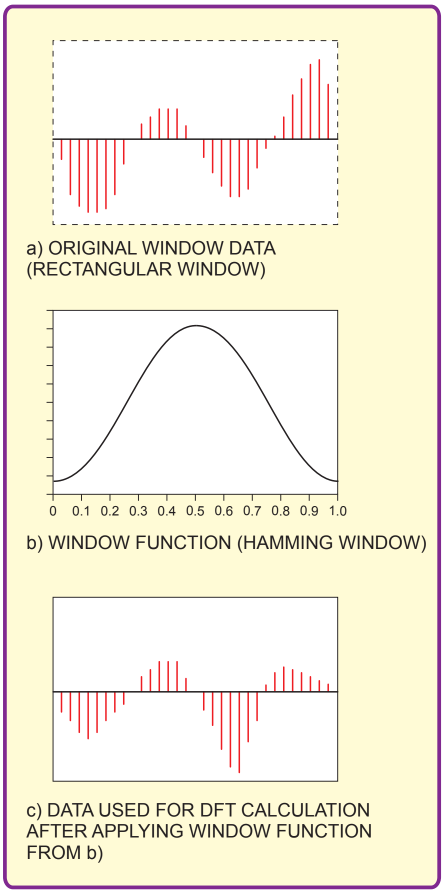


Fig.6. Applying a window function to the set of data used to produce the spectrum can improve the quality of the spectrum by reducing discontinuities introduced by imposing the window

look like a histogram. Of course, if we calculate a large number of frequency points we can plot them on a graph with a smooth curve through them and get what looks like a continuous spectrum (like Fig.3).

Picket fence

It is useful to think of the spectrum as being like a histogram, with the spectrum divided into frequency bins, but unfortunately the DFT spectrum is not a perfect histogram of the frequency content of the signal. In comparison, if we were looking at the statistics of people's height, everyone between 5ft 4½in and 5ft 5½in could be classed as being 5ft 5in (put in the '5ft 5in bin' in the histogram). Everyone in this range would have an equal influence on the total height of the relevant bar on the histogram.

However, for a DFT-based spectrum frequencies close to the centre of the bin (the exact frequency at which the DFT calculation is performed) have a stronger influence on the spectrum than those in-between (see Fig.4). This would be like giving more importance in height statistics to people who were close to an exact number of inches tall, and less importance to those in-between.

The nature of the DFT means that the frequencies at which the spectrum is calculated do not necessarily coincide with the most important frequencies in the original signal. This is exasperated by the uneven weighting described earlier. The result is referred to as the picket fence effect, because the DFT spectrum is like looking at a scene through a picket fence, you can only see through the gaps, and may miss important details.

Specifically, the DFT spectrum may show peaks in the spectrum as frequencies different from the actual peaks, and the actual peaks are likely to be lower than those in the true spectrum. The shape of the weighting graph in Fig.5, may also remind you of a picket fence.

Limitation

Returning to the limitation of a finite number of samples, this is illustrated in Fig.6, which shows that the set of samples we actually use is like a window looking at part of the signal. The fact that we look at just this window, rather than the whole signal, distorts the spectrum that we observe; we can never see the true spectrum. Mathematical analysis of this distortion shows that the observed spectrum is spread out compared with the true spectrum. This is known as a *spectral leakage*. This accounts for the 'skirts', or lack of peak sharpness, which 741 observed.

The abrupt start and finish of the window shown in Fig.5 results in a large amount of spectral leakage. This can be used by decreasing the amplitude of the samples towards the end of the window. To do this, the data in the window is scaled by a windowing function, as illustrated in Fig.6.

Windowing functions can be selected in the FFT dialog in LTspice (Fig.2), and there are many to choose from. For simple repetitive waveforms like sinewaves, window functions may not help much, but the rectangular window must be aligned correctly with the waveform to get a good spectrum.

So far in this article we have referred to the Discrete Fourier Transform (DFT) many times, whereas 741's question mentioned the Fast Fourier Transform (FFT). They are, in fact, the same thing. The FFT is a very clever way of *implementing* the DFT mathematics in hardware or software.

It is very efficient and fast (hence the name of course), but it normally requires that the number of waveform data points used is a power of 2; this is not usually an onerous restriction. You will see that the 'number of data point samples in time' parameter in the LTspice FFT dialog (Fig.2) can be set in powers of two from 256 (2^8) to 16777216 (2^{24}).

In this article we have looked at some aspects of the DFT (and hence FFT), which is used by LTspice to display spectra for simulated waveforms. These ideas help us understand some of the parameters which can be set in the FFT dialog. Next month, we will look in more detail at how to use LTspice to display useful spectra.

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

ALTHOUGH electronic project construction is an all-year-round pastime, at the time of writing this piece the children are going back to school after the summer holidays, the day lengths are rapidly shortening, and it is what some regard as the beginning of the 'electronics season'. I suppose it makes sense to make use of any good summer weather while the opportunity is there, and leave indoor hobbies for times when conditions are not conducive to most outdoor pursuits. As the days shorten, it is time to dust off the soldering iron.

This is also the time of year when an indoor hobby such as electronic project construction tends to get an influx of new recruits. Any hobby can be a little intimidating for newcomers, but a highly technical hobby such as electronics is perhaps more daunting than most.

It would be misleading to say that 'there is nothing to it', but it is probably not as difficult as it might at first appear. While it makes sense to 'do your homework', and gain a basic understanding of what is involved before starting your first project, the only way of learning to build electronic projects is to 'grasp the nettle' and try building a few.

Problem of scale

As with practically any creative hobby, it will be necessary to obtain some 'tools of the trade' before getting started. Although some of the tools required are the type of thing that can be found in the toolbox of an average household, many are not. What are the tools that will be needed before work can be started on a few simple projects?

I think it is worth pointing out straight away that while many of the tools in the average toolbox will be the right type of thing for building electronic projects, they may be too large for working on most projects. There is more than a grain of truth in the old joke about the electronics company that was so successful it moved to smaller premises!

Electronic projects have become much more sophisticated and complex over the years, but most of the complexity is in the minute silicon chips at the heart of integrated circuits. Circuit boards, and the gadgets that contain them, are mostly quite small these days.

Practical consequence

The practical consequence of this is that things like the files and screwdrivers in a typical toolbox are out of proportion to many electronic projects. These tools might still be very useful from time to time, especially when building the occasional large project, but it will probably be necessary to buy something smaller for use when building small and medium-sized gadgets.

A set of miniature files, or 'needle' files (Fig.1) as they are sometimes called, are very useful. They can be used to make minor adjustments to holes that are drilled slightly off-centre, to make rectangular or odd shaped cut-outs in panels, and for tidying any slightly rough edges.

Fig.1. Needle files are often sold in sets containing a variety of shapes, but a round type is all that is needed for making cutouts. Other types can be used for tidying assorted holes

Probably most people have an electrician's screwdriver that is suitable for fitting plugs to mains leads and the like, and one of these can be very useful when building electronic projects. One or two of the very small types are likely to be even more useful though. These are needed for such things as tightening the grub screws that fix control knobs in place, and adjusting some types of preset control.

Hole truth

While virtually any hand or power drill can be used for drilling holes in cases, some are much better than others. The small size of most projects is again something that has to be borne in mind, and the fact that many projects are housed in cases made from a fairly soft plastic is also an important factor. Many projects have metal cases or plastic cases that have metal front panels, but the metal is usually aluminium, which is a relatively soft metal.

A large electric drill that is designed for making holes in brick walls is not well suited to most electronic project work. It would definitely be an example of 'using a sledgehammer to crack a nut'.

A large power drill that has speed control will probably provide good results if the speed control is set towards the slower end of its range. This is especially important when working on plastic cases. Drilling plastic using a high-speed drill is not a good idea, and you even have to be careful when cutting plastic by hand using something like a hacksaw or a coping saw.

Drilling or cutting soft plastics tends to produce a lot of friction, and the heat generated can melt the plastic. This usually produces some very rough

looking results, and the drill bit can become caked with plastic. In an extreme case, you can end up with the drill bit or saw blade welded to the case by solidified plastic.

With any power drill, mounting it in a good quality stand should give much better control, making it relatively easy to obtain precise results. If the drill has to be used hand-held, then a small cordless electric drill is a better choice.

Once again, one that has a slow speed setting or a variable speed control is likely to be easier to use and provide better results. A hand drill is relatively slow in use and may seem a bit old-fashioned, but it provides the high degree of control needed when working on the softer plastics.

When I first became interested in electronics, which was many years ago, drill bits of just three or four well chosen sizes were sufficient. However, modern components come in all shapes and sizes, and drilling their mounting holes requires drill bits in a wide range of sizes. A set of HSS drill bits from about 2mm to 10mm in diameter is the type of thing that might already be present in your set of tools, but if not, it is something that should be obtained at the outset.

The cheapest sets should be avoided as they are prone to snapping and soon become too blunt to use. A mid-range set should be adequate for drilling plastic and aluminium panels, but something more upmarket will probably be needed if you use steel cases. Working on steel cases is relatively difficult, so initially at any rate, it is probably best to avoid using them.

Stripping off

It is tempting to simply use scissors or a penknife for cutting wires or removing the plastic insulation from connecting leads, but using scissors is unlikely to give the degree of precision needed for project construction. Cutting wires with them will soon render the scissors useless for cutting anything at all. Also, removing plastic insulation using anything other than proper wire strippers is likely to damage and seriously weaken the wire.

The cheapest type of wire stripper implement is one that combines wire stripping and cutting in one tool. These tools are usually excellent for stripping insulation, but sometimes struggle when cutting very fine wires. They make a good 'first buy' though, and if necessary a pair of wire cutters can be purchased later. Some quite sophisticated wire cutters are available, such as the spring-loaded type (Fig.2 – bottom). A pair of 'bog standard' miniature wire cutters (Fig.2 – top) will suffice though.

Wire strippers have notched blades that leave an aperture for the wire (Fig.3). The size of the aperture can usually be adjusted to suit the particular wire in use. The strippers should be set to almost cut through the insulation so that the unwanted section is easily broken free, leaving the wire or wires undamaged.

The aperture control might have some form of wire gauge calibration, but in practice this is not usually very helpful because multistrand connecting wire is used in most projects. These leads are more flexible because they have several fine wires rather than one thick one. Finding the best setting is usually a matter of trial and error.

Hot topic

It is unlikely that a soldering iron suitable for electronic work will be found in the average toolbox. A small electric iron having a rating of about 15W to 20W is the usual choice for electronic project building.

The very cheap irons that I have tried have been short-lived or simply did not generate enough heat to complete even the smallest of joints in a satisfactory manner. The operating temperature of one was barely enough to melt solder!

It is not necessary to go to the opposite extreme and buy an expensive temperature controlled iron. An iron of this type will do an excellent job, but is perhaps a bit 'over the top' for occasional project building. An iron of this type could cost more than the parts for your first few projects!

A name which is synonymous with soldering is Antex, and their soldering irons are widely available in the UK. I have been using Antex irons from their 'C' series for longer than I

Fig.2. The spring-loaded wire cutters (bottom) and the conventional type (top) will both do the job well, but the conventional type is all that is really needed for electronic project work

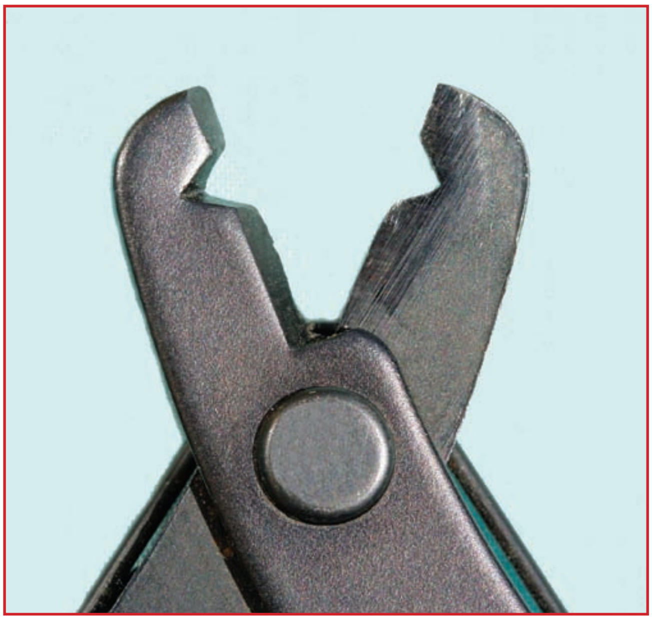


Fig.3. The notched blades of wire strippers should prevent damage to the wires. It is usually possible to adjust the size of the aperture formed when the blades are fully closed

care to remember, and they represent a safe choice that is reasonably inexpensive and will do a good job. An Antex soldering kit, which includes an iron, some solder, instructions, and the all-important soldering iron stand, is ideal for beginners.

Do not underestimate the importance of a proper stand for the iron. The stand keeps the hot iron safe when you are not actually soldering connections, and it also acts as a heatsink that helps to prevent the iron from overheating.

Some useful information about soldering and soldering equipment can be found at the Antex website (**www.antex.co.uk**) in the Technical – Papers section. Another 'must' to checkout is Alan Winstanley's widely acclaimed *Soldering Guide* at **www.epemag.wimborne.co.uk/solderfaq.htm**

A small but important point is that with most soldering irons it is essential to apply a small amount of solder to the tip of the bit as soon as it reaches its operating temperature for the first time. Otherwise the bit might oxidise, causing molten solder to run straight off it. This makes it impossible to produce good joints until the tip has been cleaned and some solder has been applied. Cleaning the bit properly without damaging it can be difficult, and is best avoided.

Desoldering

In an ideal world, we would all get everything right first time, but in the real world a desoldering tool is something that most of us need soon after completing our first soldered connection. Experience suggests that the only inexpensive type of desoldering tool that works really well is a desoldering pump.

Having first used a soldering iron to melt the solder, the spring-powered pump is then used to suck the molten solder from the joint. Provided it is not allowed to get seriously clogged with bits of solder, an inexpensive desoldering pump should last for many years.

Age-old problem

In the past, tweezers and some form of magnifying glass were sometimes recommended for electronics enthusiasts who were 'not as young as you used to be'. Due to the ever decreasing size of modern components, I would guess that most project builders would find these useful from time to time. Due to the small size of modern components it can also be difficult to pick them up, and even more difficult to accurately manoeuvre them into position.

Practically any small tweezers will do, but metal ones are better than the plastic variety in the current context. Plastic tweezers tend to be less durable, and might melt if used to hold something that gets hot.

The type of magnifier that has the lens on a flexible arm is certainly worth trying. These are mounted on the edge of the worktop using something that is a bit like an outsize crocodile clip, thus permitting hands-free use. It usually takes a while to get used to working with a magnified view of things, and the exaggerated hand movements you see via the magnifier, but you get the hang of things after a little practice.

An 8× or 10× magnifying loupe is useful when searching for short-circuits on circuit boards, and trying to read minute lettering on miniature components. These can be obtained from some suppliers of craft and hobbyist tools, and from photography shops.

Finally

Most households are probably equipped with at least one pair of pliers, and this is a tool that will certainly be needed when building projects. Ideally, you should have at least a pair of electricians' pliers and a small long-nosed type.

Many modern semiconductors are vulnerable to damage by static charges in the environment. This is a topic that has been covered recently, so it will not be considered in detail here. However, before using any expensive semiconductors it is worth investing in an earthed wristband (Fig.4), and perhaps an earthed work mat as well in due course.

Although, strictly speaking, they are not tools, before embarking on your first project it is a good idea to purchase some multistrand insulated connecting wire and some single strand non-insulated wire. The usual choice for connecting wire is the 7/0.2 variety, which has seven strands of 0.2mm diameter wire. Some 20swg (0.914mm) or 22swg (0.711mm) tinned copper wire is useful for making link-wires on printed circuit boards.

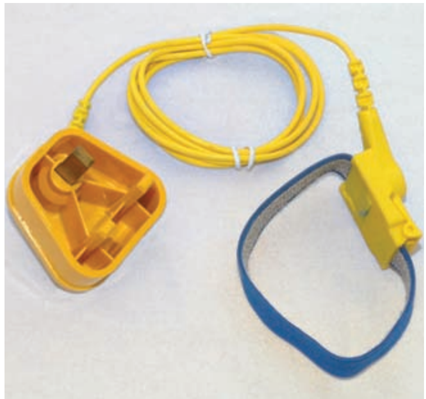


Fig.4. An earthing wristband can be obtained quite cheaply these days, and enables sensitive components to be handled without fear of 'zapping' them

Before making a start on your first project it makes sense to ensure that you have the tools and materials for the job. Building electronic projects should be fun, but it will become tedious if you have to keep stopping to buy a new tool, some more wire, and so on.

On the other hand, avoid getting overzealous. There is no point in purchasing a huge collection of tools and gadgets, some of which may never be needed. Only buy the less general and expensive tools as the need arises.

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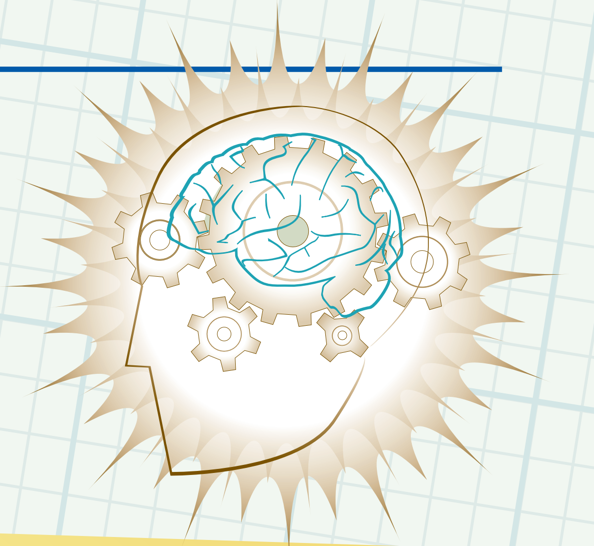

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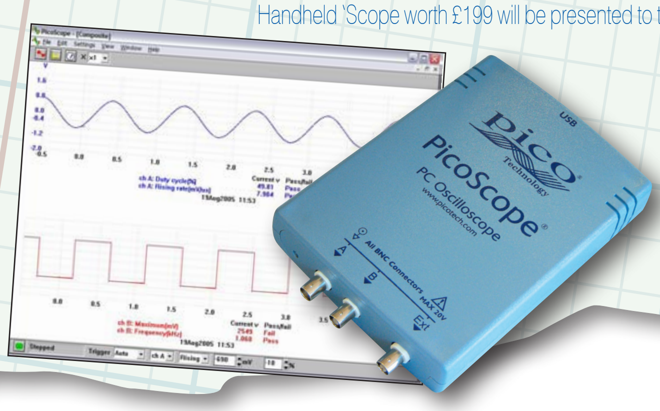

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Seeing Eye – *Flexi-vision*

THE Seeing Eye (see Fig.1 – sorry about the pun!) responds to minute fluctuations in light level, auto-adjusting over the range of about 200 lux to 10,000 lux (a modestly lit room to bright shade).

Since virtually every motion around us causes such fluctuations (except when it is dark), it has a very wide range of possibilities. It will respond, for instance, to a car entering a driveway, a person moving in a room, or wind rustling the leaves of a tree. It has a high level of rejection of natural light variations, such as sunrise, sunset, or the movement of clouds.

Flexible response

While this is a 'passive' system, it may also be used as an 'active' system – that is, in conjunction with a light beam. Its great advantage here is that, since it responds to *fluctuations* in light level, rather than the crossing of a specific light threshold, it is much more flexible than a typical 'active' system. It may be placed within the line-of-sight of almost any light source, including vague ambient light, and simply switched on without any adjustment.

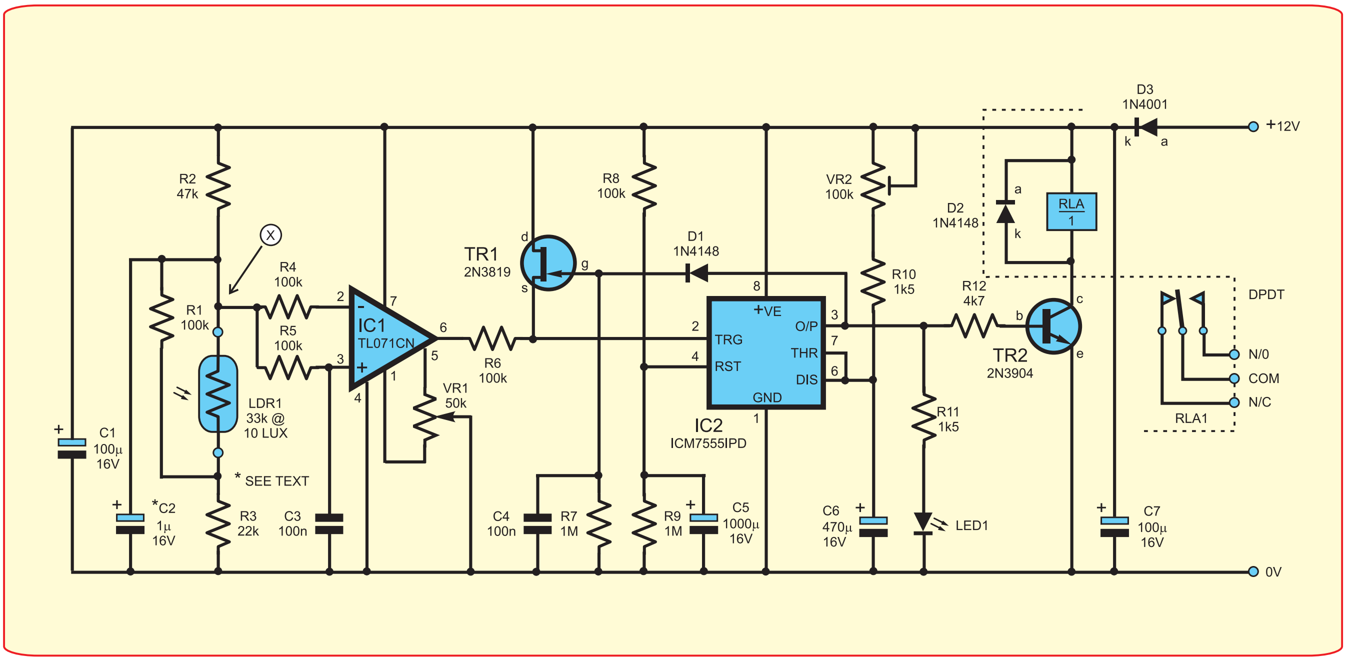

Fig.1.Complete circuit diagram for the Seeing Eye

In daylight, the circuit will typically detect a single finger moving at a distance of two metres – without the use of any lenses. It will also detect a person crossing a path at 10 metres distance – without lenses. Under AC lighting, as an 'active' system, it will typically detect a person walking in front of an ordinary light source at more than 10 metres – without the use of lenses. This range is achieved by sliding a black tube over the light dependent resistor (LDR) as shown in Fig.2.

Circuit description

The full circuit diagram for the Seeing Eye is shown in Fig.1. The light-dependent resistor (LDR1) is wired in conjunction with resistors R1 to R3 so that, between darkness and full sunlight, it offers a potential at point *X* of between roughly one-quarter and three-quarters of the supply voltage.

The present circuit differs from the more usual 'passive' light sensor in that it uses the offset-adjust feature of comparator IC1 to balance the inputs instead of a potential divider. This makes for a more sensitive and reliable circuit. A wide variety of sensors may be used in place of the specified LDR, including phototransistors, photo-diodes and infrared and ultra-violet devices.

The potential at point *X* is presented simultaneously, through resistors R4 and R5, to the inputs of comparater IC1. As the potential fluctuates at point *X*, the changes in potential are delayed at the comparator's non-inverting input (pin 3) through capacitor C2. Thus an imbalance occurs, causing the output of the compator to go 'low'. Hence, monostable timer IC2 is now triggered, switching relay RLA. Timer IC2 may be adjusted by means of trimpot VR2, to hold the relay closed between about three and 30 seconds.

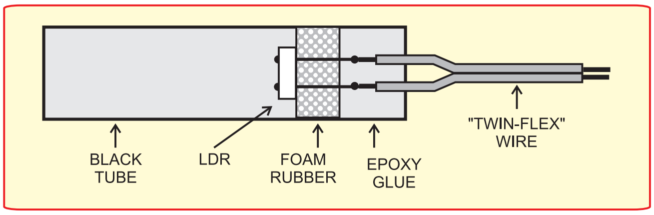

Fig.2.Suggested method for fixing the LDR inside a black plastic tube for increased range

Problems solved

As with all such circuits, the Seeing Eye may not work as well under AC lighting compared to natural lighting. If AC lighting should prove to be particularly problematic, a capacitor (say 1μF) may be added between point *X* and 0V, to smooth the potential presented to comparator IC1's inputs.

Because the circuit is very sensitive, a special problem presents itself in the form of relay RLA, which carries a relatively heavy current when switched by monostable IC2. This would ordinarily upset the circuit and reduce its sensitivity.

Beside the use of supply decoupling, this problem is overcome by 'blanking' the relay's action through transistor TR1, which disables the trigger input of timer IC2, thus allowing the circuit to settle after relay RLA has disengaged. The 'blanking' also makes it possible to run external circuits off the same power supply as the the Seeing Eye. Current consumption is nearly 20mA on standby, so that unless the circuit is run off a car battery, a 12V 'plugpack' adapter is recommended.

Setting up

Switch on, and wait for the circuit to settle and come to life (capacitor C5 first needs to charge). Adjust potentiometer VR1 for good sensitivity. The Seeing Eye will work best in situations of good contrast (eg, shadows on a white wall). It would be best to adjust it to less than its maximum sensitivity, to exclude any unwanted triggering.

With some experimentation, it may be set to transition seamlessly from natural to AC lighting – but this, unfortunately, will not occur at maximum sensitivity for both. If maximum sensitivity under natural lighting triggers the circuit under AC, then adjust for maximum sensitivity under AC – and vice versa.

Thomas Scarborough,
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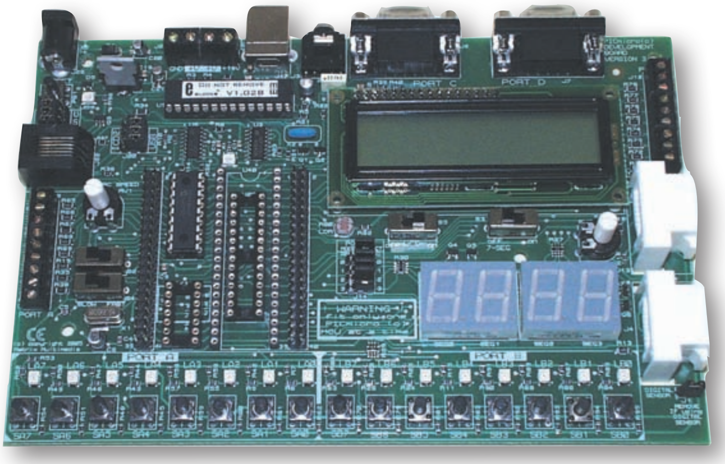
- USB programmable
- Can be powered by USB (no power supply required)



£158 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

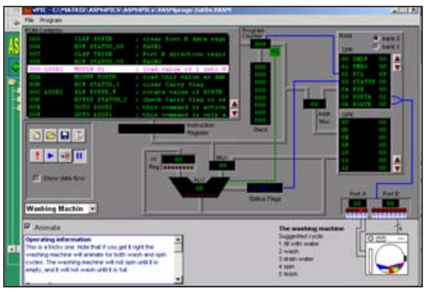
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

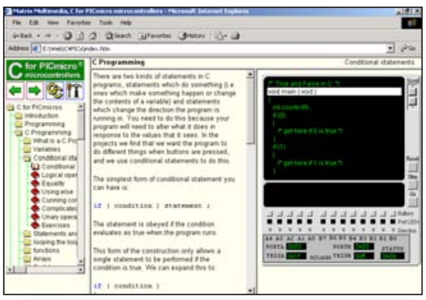


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



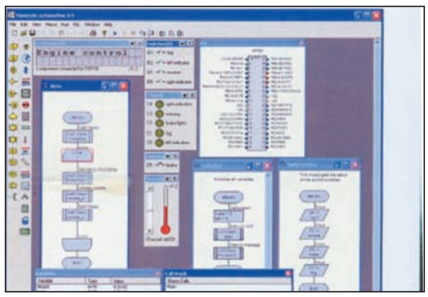
Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
- Allows complex PICmicro applications to be designed quickly
- Uses international standard flow chart symbols
- Full on-screen simulation allows debugging and speeds up the development process.
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- 16-bit arithmetic strings and string manipulation
- Pulse width modulation
- I2C.

New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

(UK and EU customers add VAT at 17.5% to 'plus VAT' prices)

Hobbyist/Student	£45	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional/Professional 10 user (Network Licence)	£350	plus VAT
Site Licence	£699	plus VAT
Flowcode Institutional (Schools/HE/FE/Industry)	£149	plus VAT
Flowcode 10 user (Network Licence)	£399	plus VAT
Flowcode Site Licence	£799	plus VAT

READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

WIN AN ATLAS LCR ANALYSER WORTH £79

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd, will be awarded to the author of the Letter Of The Month. The Atlas LCR automatically measures inductance from 1mH to 10H, capacitance from 1pF to 10,000μF and resistance from 1Ω to 2MΩ with a basic accuracy of 1%. www.peakelec.co.uk

★ LETTER OF THE MONTH ★

Maths? – no need to apologise!

Dear Editor

When I first read September's *Editorial* and the apology for the inclusion of mathematics in the *Circuit Surgery* article, I wondered what advanced mathematical analysis had been included that needed such an apology – a calculus solution of damped LCR circuits? Cauchy-Euler equations? Legendre's equation? Gamma functions? No! When I read the excellent article there was just some simple elementary mathematical analysis. The article didn't even provide the method for the solution of the Vrms equation!

Is the state of mathematical education (particularly in this country) now so bad that a magazine with the high international reputation of *EPE* deems it necessary to include an apology for this? Personally, I would welcome the inclusion of more mathematics – especially in the *Circuit Surgery* articles.

Perhaps *EPE* could champion mathematics education by highlighting mathematics' relevance to real world problems (often lacking in mathematical education). For example, a 'Maths Teach-in' series in a similar style to your previous 'Teach-in' series on microprocessor programming.

John Taylor, by email

Thank you John; re-reading my editorial I don't think I would classify it as an 'apology', but I do take your point as to its cautious tone. The reasoning behind this was not concern about the ability of readers, but that it represented a new departure for EPE. *We rarely include mathematics because it is rarely needed for the 'hands on' style of* EPE.

Electronics is unusual in that it is possible to design and build sophisticated projects with fairly basic maths. That said, there are some fascinating areas of electronics that can be opened up with just a little of the more advanced areas of mathematics. 'Complex numbers' are a good example, which despite their off-putting name can be manipulated quite easily once you get the hang of them.

We will consider more mathematics, but it is also important that we stick to what we do best – providing high quality electronics projects, together with practical advice on how to design and build circuits. There are comparatively few publications like EPE, but libraries full of a vast range of mathematics books for all abilities and levels. We cannot cover every aspect of electronics, however much we would like to, and this fact of life means that we need to draw a line somewhere.

In the meantime, for those who would like an excellent free mathematics resource, I repeat last month's News *recommendation of the following website:* **www.khanacademy.org**. *While this website has little to do with electronics, it does cover many areas of interest to electronic engineers; from basic algebra and trigonometry, to more advanced areas such as complex numbers and calculus, including differential equations.*

POV hard disk use and stripboard techniques

Dear Editor

The POV hard disk idea caught my eye (*Readout*, Sep '10). Mr Zahra might like to check out a digital clock along similar lines, made by etching the digits into a drive platter spun in front of LEDs. These are strobed at the right time to present a digital readout of the time (including a flashing colon). See: **http://tinyurl.com/3yu4dsz**

Moving on to *Practically Speaking* (use of stripboard, Sep'10) it is worth noting that one does not have to reserve an entire row or three for corner mounting holes, just the corners! I insulate the strips from any possible shorting to the screws by breaking the tracks a few holes away from the screws. Also, it is possible to overcome the problem with precision drilling of the mounting points. The drill will be guided to the right place on the stripboard, but by making the holes a little over-sized there is an allowance for inaccuracy in the position of the mounting pillars or holes in the chassis. Never do the screws up tight, allow a little movement for settling, ageing, thermal expansion.

I have managed to nearly double the circuit capacity of a piece of stripboard – usually constrained in size by the space you have to mount it – by cutting the tracks not at a hole but between holes. For this I use a milling bit on an electric rotary hand tool. It is also possible to do it with a knife: make two parallel cuts and pick out the copper between them – but mind your fingers!

High-density component placement requires high-density interconnection, and I achieve this by wiring on the copper side using fine wire with meltable insulation (known as Verowire). This is carefully soldered without being stripped – but watch out for vulnerable adjacent wires. Wire sold for wire-wrap is also suitable, but does require stripping. A fine hot-melt glue gun is useful for tacking the wire runs in place. This sort of thing is not suitable for high frequency or audio work, but is eminently satisfactory for the majority of hobbyist digital circuits.

One final tip: it is possible to mount 0.05-inch pitch surface-mount devices (eg SOIC packages) on 0.1-inch stripboard without adapters. With the trusty milling bit, split the copper strip into two by joining up the holes. This does, of course, need copper-side hook-up wiring described above to be practical.

Keep up the good work

Ken Wood, by email

Impressive ideas Ken, there is little chance of stripboard becoming out of date with your flexible and imaginative approach to using modern components. I have never seen 'split' stripboard used with fine pitch components such as the ones you describe – do please send us a photo!

Are there any other readers out there with novel stripboard techniques? – again, a photo is often the best way to describe ideas, so do please include them with your letters or emails.

Net Work

Alan Winstanley

Back to the future

Last month, I mentioned ways in which the Internet can help readers to make headway during these challenging and recessionary times. For example, eBay sometimes offers fee-free listing days, a low-cost way of advertising unwanted gear or bric-a-brac (or maybe snapping up a bargain), giving your PayPal account a useful fillip.

For those in the job-hunting market, recruitment websites are the prime way of hearing about new jobs or submitting your CV/ résumé in the hope of finding a match. Not surprisingly, some recruiters profile their job applicants by searching the web, especially at social networking sites like Facebook. Regrettably, Facebook can become a showcase (good or bad) of its participants' lifestyles. Many Facebook users pour out their everyday life all too eagerly: certainly, posting the latest trivia into one's Facebook page can be enjoyable bond-forming stuff, but it can backfire by revealing rather more about us than is wise, especially if it's being read by a recruiter some time into the future.

Good recruitment practice says that job applicants should be told whether any online researching will be undertaken, but such is the threat to individual privacy that the German legislature recently banned potential employers from checking personal Facebook profiles when making hiring decisions.

Probably the most powerful life tool available to empower individuals and businesses today is still the art of *networking*. Many surprising new opportunities appear, and much new business is generated, by getting around and networking in the right places. It's therefore highly beneficial to be well connected in today's wired world, especially if you're a graduate in the job-hunting market. If you want to 'get connected', then one site that should be top of your list is LinkedIn (**www.linkedin.com**). It helps offer a more 'professional' view of you and you can connect with like-minded individuals, as well as unearthing useful contacts from the past.

For example, through LinkedIn I recognise customers and supplier contacts from years ago that have sought and located me on LinkedIn: it could do the same for you. If you're a job hunter or a professional then it's worth spending some quality time on LinkedIn, and nurture your online presence with care, in the hope of reaping future dividends in your career.

Power to the people

The financial sector is one of the largest on the web, with major brands pumping many tens of millions into online advertising. There is, however, an awful lot of low-grade 'noise' out there, and so to help make sense of it all, don't overlook financial advice forums, including **moneysavingexpert.com** or **moneysupermarket.com**. While these are UK sites, there will certainly be equivalents in other countries. The useful 'Motley Fool' financial websites cover both the UK and USA (**fool.co.uk/ .com**).

Before buying online, see if any online review sites (start with Amazon) can provide you with practical feedback from existing owners, so that you avoid buying a lemon. Remember your Distance Selling Directive 7 Day cooling off period in the EU: for many items you could receive a full refund, including the original postage cost. Some shopping carts allow a discount voucher code to be used and websites that share these codes include **discountvouchers.co.uk** and **myvouchercodes.co.uk**, or local equivalents.

And one thing that our hobby would be very much the poorer without: electricity! Many of the utility providers now offer the best savings for those managing their accounts online. It's worth getting to know your kilowatt-hours (kWh) and your 'standing charges' and it helps to know the last 12 months' usage (eg Scottish Power displays customer usage data for the last two years, and you can enter meter readings online), then input them into a comparison website such as **uSwitch.com**. Again, see what others recommend in the money-saving forum sites. Several power-monitoring devices are also available, including some wireless or USB types that download data onto your PC, perfect for *EPE* readers!

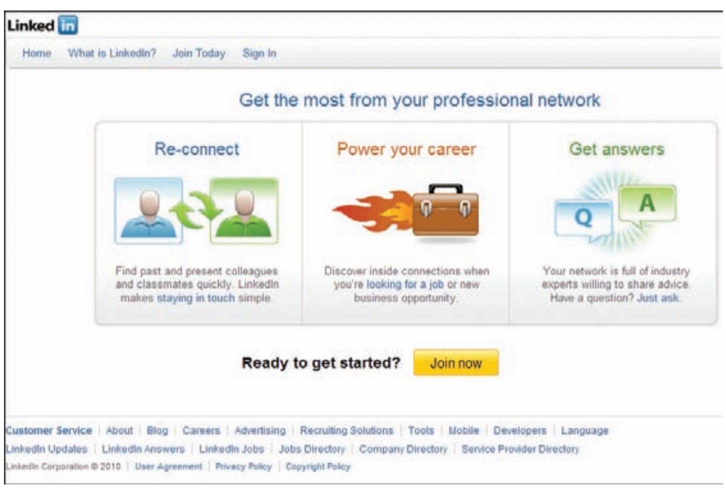
Our telecoms costs can be scrutinised as well. Now might be a good time to re-visit existing contracts and see if unnecessary waste can be screened out. Apart from facing a myriad of mobile phone tariffs, some might consider Voice over Internet Protocol (VoIP) including Skype (**www.skype.com**) which offers free Skype-to-Skype calls over broadband.

You could also try a Skype-compatible VoIP handset that connects via a USB port, or use a decent USB webcam with built-in microphone (Logitech and Microsoft offer excellent ones) for calling friends and family, especially overseas. A netbook might have a webcam and sound built in. You can call landlines and mobiles through Skype for one to two pence per minute with a small connection fee, with pay-as-you-go and monthly subscriptions being available. Business users can benefit from Skype Manager, or integrate VoIP into their PBX using Skype Connect. Vonage (**www.vonage.co.uk**) offers IP-based phone calls using ordinary home phones connected to a Vonage adaptor box, which hooks to your ADSL. They serve the UK, USA and Canada.

Don't forget to look at your broadband rates too – find out when your lock-in period finishes and then look for a better deal (possibly with the same provider). If your email address is supplied by them then you need to plan ahead, with a view to changing it and notifying your contacts some time in the future.

With the world-wide web literally at your fingertips, it has never been easier to shop around, compare, manage accounts online, check reviews, buy or sell your stuff, search for a better job or switch to another supplier!

Remember to check the *EPE Chat Zone* forum at **www.chatzones.co.uk**. You can email me at: **alan@epemag.demon.co.uk**, check my own work in progress site at **www.epemag.net** or write to the Editor at: **editorial@wimborne.co.uk**. See you next month for more gossip!



LinkedIn is a website that brings together professionals of all disciplines, offering valuable networking opportunities and a chance to catch up with old contacts

DIRECT BOOK SERVICE

NEW

Electronics Teach-In 3

FREE CD-ROM

The three sections of this book cover a very wide range of subjects that will interest everyone involved in electronics, from hobbyists and students to professionals. The first 80-odd pages of Teach-In 3 are dedicated to *Circuit Surgery*, the regular *EPE* clinic dealing with readers' queries on various circuit design and application problems – everything from voltage regulation to using SPICE circuit simulation software.

The second section – *Practically Speaking* – covers the practical aspects of electronics construction. Again, a whole range of subjects, from soldering to avoiding problems with static electricity and indentifying components, are covered.

Finally, our collection of *Ingenuity Unlimited* circuits provides over 40 different circuit designs submitted by the readers of *EPE*.

The free cover-mounted CD-ROM is the complete *Electronics Teach-In 1* book, which provides a broad-based introduction to electronics in PDF form, plus interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In 1 series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In 1 series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC. There is also a MW/LW Radio project in the series.

The contents of the book and Free CD-ROM have been reprinted from past issues of *EPE*.

CD-ROM **Order code ETI3** **£8.50**

CIRCUITS AND DESIGN

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements.

256 pages **Order code BP53** **£5.49**

MICROCONTROLLER COOKBOOK
Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** **£36.99**

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS AND CDROMS SEE THE UK SHOP ON OUR WEBSITE
www.epemag.com

All prices include UK postage

2

EASY PC CASE MODDING
R.A Penfold

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages + CD-ROM **Order code BP542** **£8.99**

COMPUTING AND ROBOTICS

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and home editions.

The book was written with the non-expert, busy person in mind. it explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, notepad and paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; how to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

264 pages **Order code BP514** **£7.99**

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages + Large Format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision command system

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages **Order code BP902** **£14.99**

THE PIC MICROCONTROLLER YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages **Order code NE36** **£25.00**

INTRODUCTION TO MICROPROCESSORS AND MICROCONTROLLERS – SECOND EDITION
John Crisp

If you are, or soon will be, involved in the use of microprocessors and microcontrollers, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors and micrcontrollers. Assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern micros.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

222 pages **Order code NE31** **£29.99**

ROBOT BUILDERS COOKBOOK
Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

366 pages **Order code NE46** **£26.00**

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation. Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems; Temperature; Light; Position and motion; Force, pressure and flow. Part 2 – Interfacing; Number systems; Computer architecture; Assembly language; Interfacing; A to D and D to A conversions; Data communications; Programmable logic controllers; Data acquisition project. Part 3 – Signal processing; Transfer function; Active filters; Instrumentation amplifier; Noise; Digital signal processing.

295 pages **Order code NE38** **£41.00**

THEORY AND REFERENCE

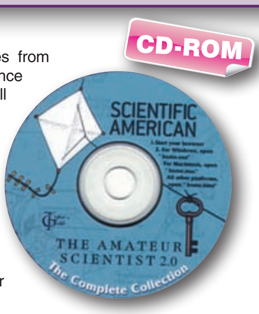
THE AMATEUR SCIENTIST CD-ROM

The complete collection of The Amateur Scientist articles from Scientific American magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.

Plus over 1,000 pages of helpful science techniques that never appeared in Scientific American.

Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems.

Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher.



Over 1,000 projects **Order code AS1 CD-ROM** **£19.95**

OSCILLOSCOPES – FIFTH EDITION
Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.

This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.

The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscilloscopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages **Order code NE37** **£36.99**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money

In most applications of electronics, test instruments are essential for checking the performance of a system or for diagnosing faults in operation, and so it is important for engineers, technicians, students and hobbyists to understand how the basic test instruments work and how they can be used.

The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.

206 pages **Order code PC109** **£9.95**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

228 pages **Order code NE35** **£36.99**

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FULL COLOUR COMPUTING BOOKS

HOW TO FIX YOUR PC PROBLEMS **R.A. Penfold**

What do you do when your laptop or desktop stops working properly. Do you panic, try to find the answer on the page of fault finding tips you may find at the back of the manufacturers manual. Or do you spend hours trying to get through to a telephone helpline or waste even more time waiting for an email reply from a helpdesk.

Well help is now at hand! This book will assist you in identifying the type of problem, whether it's hardware, software or a peripheral that is playing up? Once the fault has been identified, the book will then show you how to go about fixing it. This book uses plain English and avoids technical jargon wherever possible. It is also written in a practical and friendly manner and is logically arranged for easy reference.

The book is divided into four main sections and among the many topics covered are: Common problems with Windows Vista operating system not covered in other chapters. Also covers to a lesser extent Windows XP problems. Sorting out problems with ports, peripherals and leads. Also covers device drivers software and using monitoring software. Common problems with hard disc drives including partitioning and formatting a new drive. Using system restore and recovering files. Also covers CD-ROM and Flash drives. Common problems with sound and video, including getting a multi-speaker system set up correctly.

An extremely useful addition to the library of all computer users, as you never know when a fault may occur!

Printed in full colour on high quality non-refective paper

128 pages **Order code BP705** **£8.49**

AN INTRODUCTION TO WINDOWS VISTA **P.R.M. Oliver and N. Kantarris**

If you have recently bought a new desktop or laptop it will almost certainly have Windows as its operating system. Windows Vista manages the available resource of a computer and also 'controls' the programs that run on it.

To get the most from your computer, it is important that you have a good understanding of Vista. This book will help you acheive just that. It is written in a friendly and practical way and is suitable for all age groups from youngsters to the older generation. It has been assumed that Vista is installed and running on your computer.

Among the numerous topics explained are: The Vista environment with its many windows. How to organise your files, folders and photos. How to use Internet Explorer for your web browsing. How to use Microsoft Mail for your emails. How to control your PC and keep it healthy. How to use Vista's Accessibility features if you have poor eye sight or difficulty in using the keyboard or mouse. And much more besides....

With the help of this book you will easily and enjoyably gain a better understanding of Microsoft's amazing Windows Vista operating system.

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120 pages **Order code BP703** **£8.49**

COMPUTING WITH A LAPTOP FOR THE OLDER GENERATION **R.A. Penfold**

Laptop computers have rapidly fallen in price, increased in specification and performance and become much lighter in weight. They can be used practically anywhere, then stored away out of sight. It is therefore, not surprising that laptop sales now far exceed those of desktop machines and that they are increasingly becoming the machine of choice for the older generation.

You may want to use your laptop as your main computer or as an extra machine. You may want to use your laptop on the move, at home, at work or on holiday. Whatever your specific requirements are, the friendly and practical approach of this book will help you to understand and get the most from your laptop PC in an easy and enjoyable way. It is written in plain English and wherever possible avoids technical jargon.

Among the many topics covered are: Choosing a laptop that suits your particular needs. Getting your new computer set up properly. Customising your computer so that it is optimised for your particular needs. Setting up and dealing with user accounts. Using the Windows 'Ease of Access Center'. Optimising the life and condition of your battery. Keeping the operating system and other software fully up-to-date. Troubleshooting common problems. Keeping your computer and data safe and secure. And much more besides...

Even though this book is written for the older generation, it is also suitable for anyone of any age who has a laptop or is thinking of buying one. It is written for computers that use Windows Vista as their operating system but much will still apply to Windows XP machines. Printed in full colour on high quality non-refective paper

120 pages **Order code BP702** **£8.49**

AN INTRODUCTION TO EXCEL SPREADSHEETS **Jim Gatenby**

The practical and friendly approach of this book will help newcomers to easily learn and understand the basics of spreadsheets. This book is based on Microsoft's Excel 2007 spreadsheet, but much of the book will still apply to earlier versions of Excel. The book is written in plain English, avoiding technical and mathematical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Install the software. Use the exciting new features of Excel 2007. Create and use a spreadsheet. Enter, edit and format text, numbers and formulae. Insert and delete columns and rows. Save and print a spreadsheet. Present the information on a spreadsheet as a graph or chart. Manage and safeguard Excel files on disc. Use Excel as a simple database for names and addresses.

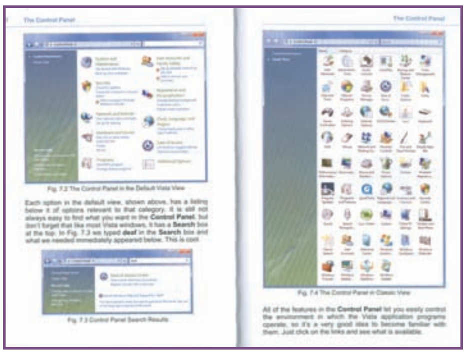
This book will help you to quickly gain confidence and get to grips with using spreadsheets. In fact, you will wonder how you ever managed without them.

Printed in full colour on high quality non-reflective paper.

118 pages **Order code BP701** **£8.49**

AN INTRODUCTION TO DIGITAL PHOTOGRAPHY WITH VISTA **R.A. Penfold**

The friendly and practical approach of this book will help newcomers to digital photography and computing to easily learn the basics they will need when using a digital camera with a laptop or desktop PC. It is assumed that your PC uses Windows Vista, however, if it is a Windows XP machine the vast majority of this book will still apply. The book is written in plain English, avoiding technical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.



Among the many topics explained are how to: Understand the basic features of a digital camera. Transfer photographs from your digital camera to your computer. View your photographs. Save, sort and file your photographs. Manipulate, crop and carry out simple corrections to your photographs. Copy your photographs on to CD or DVD. Print your photographs. Share images with family and friends anywhere in the world by email or with an online album.

This book will help you quickly get to grips with, gain confidence and expand your horizons in the fascinating hobby of digital photography.

Printed in full colour on high quality non-reflective paper.

120 pages **Order code BP700** **£8.49**

PROJECT BUILDING

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

Temporarily out of print

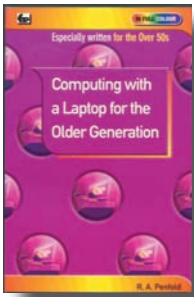
BUILDING VALVE AMPLIFIERS
Morgan Jones

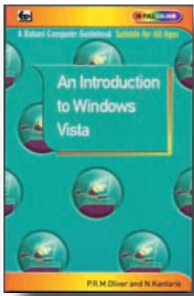
The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£29.00**





PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

HOW TO BUILD A COMPUTER
R.A. Penfold

To build your own computer is, actually, quite easy and does not require any special tools or skills. In fact, all that it requires is a screwdriver, pliers and some small spanners rather than a soldering iron! The parts required to build a computer are freely available and relatively inexpensive.

Obviously, a little technical knowledge is needed in order to buy the most suitable components, to connect everything together correctly and to set up the finished PC ready for use. This book will take you step-by-step through all the necessary procedures and is written in an easy to understand way. The latest hardware components are covered as is installing the Windows Vista operating system and troubleshooting.

320 pages **Order code BP591** **£8.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£5.45**

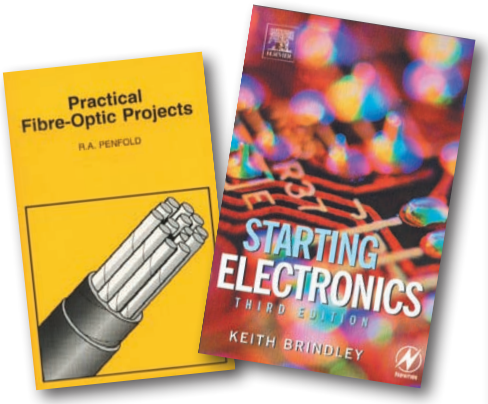
THEORY AND REFERENCE

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**



STARTING ELECTRONICS
Third Edition
Keith brindley

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£13.99**

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NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photocopies of articles are available if required – see the Back Issues page for details. WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.

Please check price and availability in the latest issue.
A large number of older boards are listed on, and can be ordered from, our website.

Boards can only be supplied on a payment with order basis.

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★ Random Mains Timer	724	£9.51
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1pps Driver for Quartz Clocks	725	£5.71
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– Ignition Unit	727 } set	
– Ignition Coil Driver	728 } set	£11.10
– LCD Hand Controller	729 } set	
★Guitar-To-MIDI System	730	£6.66
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– PSU	732 } set	
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A handy circuit that can be used as a speed controller for a 12V motor (up to 5A continuous) or a dimmer for a 12V halogen or incandescent lamp rated up to 50W.

USB CLOCK WITH LCD READOUT – PART 2

Next month, we detail the software installation and describe how the clock is used. Plus, how to synchronise your PC to an internet time server, and the USB Clock to the PC at boots up.

MULTI-PURPOSE CAR SCROLLING DISPLAY

A project for any measurement or data logging application where you have 9-12V DC available. It can monitor up to six signals and display up to 10 computed values in a scrolling or static readout on a 7 x 15 dot matrix LED display.

MUSICOLOUR IRDA ACCESSORY

How to add a wireless infrared port to the DSP Musicolour – or in fact virtually any microcontroller project

TEACH-IN 2011 – PART 2

Mike and Richard Tooley continue our indispensable back-to-basics series with a look at resistors, capacitors, timing and delay circuits.

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